BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Aeronautical Engineering REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

January, 1953

How the Holley Turbine Control helps jet pilots concentrate on FIGHTING, not flying

Nearly every foot of altitude, gained or lost, nearly every minute change in atmospheric conditions alters the amount of fuel flow needed by today's jet engine. Literally hundreds of mathematical problems must be solved every minute a jet is in the air. It would be impossible for any pilot to solve all these problems and still have time to concentrate on fighting. So the Holley Turbine Control was developed to solve them for him AUTOMATICALLY.

Holley's research department played an important role in the development of this mechanical wizard. But producing Holley Turbine Controls requires special skills, too. Working to tolerances of as little as plus or minus 25 millionths of an inch, the Holley manufacturing division turns out turbine controls for thousands of today's jet aircraft.

Holley's highly-trained research, engineering and manufacturing staff can support your program of producing better products for the aviation industry, either your design or ours.

Leader in the design, development, and manufacture of aviation fuel metering devices.

HOLLEY Carburetor Co.

VAN DYKE, MICHIGAN

A-19

Aeronautical Engineering Review

Vol. 14—No. 1 January, 1955

CONTENTS

Instrumentation for Jet Transports ..... *Christopher Dykes* 24

Control Stick Steering for Stabilized Aircraft ..... *Ben H. Ciscel* 33

Tooling Aspects of Heavy Skin Construction ..... *C. S. Glasgow* 38

The Orenda and the Future ..... *B. A. Avery* 46

Flying Techniques with the Research Airplanes ..... *A. Scott Crossfield* 56

IAS News Notes 17
IAS News 19
Editorial 22
Sherman M. Fairchild Publication Fund Papers 55
Aeronautical Reviews 95
Books 121
Personnel Opportunities 127
Index to Advertisers 133
New Products and Product Literature 135

Cover—The X-1B has joined its sister ship, the X-1A, at Edwards AFB, Calif., where both are being used in continuing the Air Force's high-speed high-altitude research program. These flying laboratories were designed for the Air Force by Bell Aircraft Corporation and are powered by rocket engines built by Reaction Motors, Inc. The X-1A has been flown at 1,650 m.p.h. and to a reported altitude of 90,000 ft.

Published Monthly by the

Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

***Western Office:* 7660 Beverly Blvd., Los Angeles 36, Calif.**

KEUFFEL & ESSER CO.

EST. 1867

New York • Hoboken, N. J.

Chicago • St. Louis • Detroit
San Francisco • Los Angeles • Montreal
Distributors in Principal Cities

• Since 1867 engineers, scientists, designers, surveyors, draftsmen have relied on K&E as the foremost, most progressive, and most complete source of supply for the tools, equipment, and materials they work with. When you buy, think first of K&E, headquarters for 7,000 items. For example . . .

LEROY® LETTERING SETS

The diversity of alphabets, numerals, symbols, trademarks and other designs available from stock or made to your special order, is almost unlimited with Leroy Lettering Equipment. You can have practically anything you want.

In Leroy Lettering each letter and number can be drawn complete without shifting the template. This ease and simplicity of operation, combined with the consistent uniformity of the lettering, has made Leroy Lettering Sets a "must" in thousands of drafting rooms the country over.

I.A.S. News Notes

January 1955

LESTER D. GARDNER ELECTED HONORARY FELLOW

By a unanimous vote of the Council at its meeting in Washington, December 17, Major Lester D. Gardner was selected to receive the Institute's outstanding award of American Honorary Fellow for 1954.

Presentation of the Award will be made at the Honors Night Dinner in New York, January 24. More complete details concerning the citation of this, and other awards, will be forthcoming in later editions of the Review.

* * * * * * * *

SECTION CHAIRMEN MEETING PLANNED

A dinner meeting for the Section Chairmen of the Institute of the Aeronautical Sciences has been scheduled during the Twenty-Third Annual Meeting. It will be held at 5:30 p.m. on Tuesday, January 25, at the Hotel Sheraton Astor in New York.

Among the topics to be discussed at this meeting will be the student branch activities as they pertain to the Minta Martin Aeronautical Fund. This will include the duties of sponsors of regional student paper competitions and the standardization of various aspects of the conferences.

* * * * * * * *

IAS PLAQUE UNVEILED AT COLUMBIA

Major Lester D. Gardner, IAS Founder and longtime Chairman of the Council, presented a bronze plaque to Columbia University on Wednesday, December 22, on behalf of IAS, with several Founder Members standing by. Citing the fact that IAS was "founded in the Pupin Physics Laboratories in 1932," the plaque expresses appreciation to Columbia for its "generous hospitality for many years." It is located in the entrance vestibule of the building in which annual meetings were held for a number of years. Major Gardner spoke at the unveiling and also at a luncheon following the ceremony.

* * * * * * * *

NATIONAL MEETINGS CALENDAR

Jan. 24-28 Twenty-Third Annual Meeting and Honors Night Dinner, Hotel Sheraton Astor, New York.

Mar. 11 National Flight Propulsion Meeting (Restricted), Hotel Carter, Cleveland.

June 21-24 Fifth International Aeronautical Conference, IAS Building, 7660 Beverly Blvd., Los Angeles.

Aug. 8-10 Turbine-Powered Air Transportation Meeting, Seattle, Wash.

* * * * * * * *

I.A.S. News Notes (con't.)

CALENDAR OF SECTION MEETINGS

Jan. 11 -- Indianapolis Section: Allison Division, GMC. Dinner Meeting.

Jan. 12 -- Niagara Frontier Section: Crosby-Braunschidel Post, Kenmore. Meeting, 8:00 p.m. "Computers Come of A ge" by Dr. E. Welmers.

Jan. 12 -- Seattle Section: Social Hour, 6:00 p.m.; D inner, 7:00 p.m.; Meeting, 8:00 p.m. "Arctic Flying" by Col. Bernt Balchen, USAF.

Jan. 13 -- Baltimore Section: The Johns Hopkins University. Meeting, 8:30 p.m. "The Air Research and Development Team" by Lt. Gen. Thomas S. Power, USAF.

Jan. 13 -- Dayton Section: Gordell's Supper Club, Fairborn, Ohio. Dinner, 6:30 p.m. "Helicopters and Convertiplanes" by Paul A. Simmons and Paul E. Haueter.

Jan. 14 -- Texas Section: Baker Hotel, Dallas. Joint Meeting with SAE, 7:45 p.m. "Design Aspects of the 707 Transport" by R. D. Fitzsimmons, Boeing Airplane Company.

Jan. 17 -- Los Angeles Section: IAS Building. Confidential Specialist Meeting, 8:00 p.m. "Heterogeneous Fuselage Construction for High-Speed Missiles" by Dr. A. T. Zahorski, Aerophysics Development Corp.

Jan. 18 -- Columbus Section: Officers' Club, Port Columbus NAS. Dinner Meeting, 7:00 p.m. "Problems in Civil Transport Design" by H. D. Hoekstra, Chief Project Officer, Aircraft Engrg. Div., CAA.

Jan. 18 -- Hampton Roads Section: NACA Activities Bldg., Langley Field. Meeting, 7:30 p.m. "Integrated Flight Control Systems" by J. C. Owens, Chief Engineer, and John Harper, Engrg. Test Pilot, Grand Rapids Division of Lear, Inc.

Jan. 19 -- Chicago Section: Glenview NAS. Meeting, 7:30 p.m. "The Navy's Role in Air Defense" by Rear Adm. Austin K. Doyle, USN.

Jan. 20 -- Los Angeles Section: IAS Building. Social Hour, 6:00 p.m.; Dinner, 7:00 p.m.; Meeting, 8:15 p.m. "The Jet Transport Prototype --the Starting Point of a New Program" by Lloyd T. Goodmanson, Project Engineer, Jet Transport Prototype, Boeing Airplane Co.

Jan. 20 -- San Fransicso Section: Ramor Oaks, Atherton. Meeting, 7:00 p.m. "Sir Echo" by E. A. Post, United Air Lines.

Jan. 26 -- St. Louis Section: Engineers' Club. Meeting, 8:00 p.m. "Aviation Crash Injury Research" by Howard Hasbrook, Director, Aviation Crash Injury Research, Cornell Medical College.

Jan. 28 -- Texas Section: Fort Worth International Airport. Meeting, 7:45 p.m. "Aeromedical Problems of High-Speed Flight" by Dr. John R. Poppen, Douglas Aircraft Company.

Feb. 8 -- Los Angeles Section: IAS Building. Specialist Meeting, 8:00 p.m. "Usage of Castings in Highly Stressed Aircraft Structural Applications" by Ralph Van Deventer, Associate Project Director and Chief Materials Engineer, Alloy Engineering and Casting Company.

Mar. 1 -- Indianapolis Section: Tentative plans include talk on "Application of Nuclear Energy to Aircraft Propulsion."

* * * * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

Lockheed's R. E. Gross Elected to IAS Presidency

Four Vice-Presidents and Treasurer for 1955 Also Announced by IAS Council. New Officers to Be Installed at Institute's Annual Meeting.

ROBERT ELLSWORTH GROSS, President and Chairman of the Board, Lockheed Aircraft Corporation, has been elected to serve during 1955 as President of the Institute of the Aeronautical Sciences. He will assume his new duties at the Honors Night Dinner on January 24, when J. L. Atwood, President of North American Aviation, Inc., completes his final act as the Institute's 1954 President and turns the gavel over to his successor.

Mr. Gross will be the Institute's twenty-third President, following a line of outstanding men in the aviation field. The first on this list is J. C. Hunsaker who, as the 1933 President, presided at the IAS Founders' Meeting held at Columbia University on January 26, 1933. He was succeeded by the late Charles L. Lawrence in 1934, Donald W. Douglas in 1935, Glenn L. Martin in 1936, Clark B. Millikan in 1937, T. P. Wright in 1938, the late George W. Lewis in 1939, James H. Doolittle in 1940, Frank W. Caldwell in 1941, Hall L. Hibbard in 1942, Hugh L. Dryden in 1943, R. H. Fleet in 1944, Charles H. Colvin in 1945, Arthur E. Raymond in 1946, Preston R. Bassett in 1947, John K. Northrop in 1948, W. A. M. Burden in 1949, J. H. Kindelberger in 1950, L. B. Richardson in 1951, Wellwood E. Beall in 1952, Charles J. McCarthy in 1953, and by Mr. Atwood in 1954.

▸ **Other 1955 Elected Officers**—At the same time that Mr. Gross's election to the IAS Presidency was announced, the names of the 1955 Vice-Presidents and Treasurer were also given by the IAS Council. The four IAS Vice-Presidents who have been elected are: Roger W. Kahn, Service Manager and Test Pilot, Grumman Aircraft Engineering Corporation; T. Claude Ryan, President, Ryan Aeronautical Company; Edward R. Sharp, Director, Lewis Flight Propulsion Laboratory, NACA; and Edward C. Wells, Vice-President—Engineering, Boeing Airplane Company. The new Treasurer for this year is Charles H. Colvin, President, Colvin Laboratories, Inc. S. Paul Johnston has been re-elected Director of the Institute, while Robert R. Dexter and Joseph J. Maitan have been re-elected IAS Secretary and Controller, respectively.

These men will take over the responsibilities of their various offices at the Institute's forthcoming Annual Meeting, which runs from January 24 to 28.

▸ **The President**—A native of Boston, Mass., Mr. Gross was tutored privately at home until he reached his tenth birthday. He was then entered in the Boston public school system; however, he spent his final year of his secondary school education at St. George's School in Newport, R.I. Matriculating at Harvard University as an undergraduate student, he was graduated from there in 1919 with an A.B. degree.

After a short tour of duty with the postwar army, Mr. Gross went to work for Lee Higginson Corporation, an investment banking house. He remained with Lee Higginson for 8 years, leaving there in 1927 to organize and head a seaplane manufacturing firm known as Viking Flying Boat Company. By 1930, the depression had virtually eliminated the flying boat market.

Robert E. Gross

Meanwhile, the old Lockheed Aircraft Company, organized in 1916 by Allan and Malcolm Loughead, had been purchased by Detroit Aircraft Corporation. This merger had taken place in the predepression period. By 1932, the Detroit group was ready to dispose of its holdings in the Lockheed company. A syndicate of which Mr. Gross was a member offered to purchase the Lockheed interests. As soon as the Lockheed ownership passed over to the new group, the company was reorganized and was incorporated as Lockheed Aircraft Corporation. Mr. Gross served from 1932 to 1934 as Chairman of the Board and Treasurer; in 1934, the duties of President were added. Five years later, he was elected President and Chairman of the Board, his present positions at Lockheed.

Col. J. G. Vincent

Col. J. G. Vincent Retires

Colonel Jesse Gurney Vincent, IAS Fellow and Founder Member, retired in December of 1954 after more than four decades with Packard Motor Car Company. His association with Packard began in 1912 when he joined the organization as Chief Engineer. He was elected a company Vice-President a short time later and continued in this post until his retirement. He is now serving as Engine Consultant.

Colonel Vincent is regarded by many as the "father of American aviation engines" for his work as co-designer of the famed Liberty engine. The Liberty was developed in 1917 from the Packard 905, an engine that had been designed in the 1915–1917 period by Packard's Aircraft Engine Department.

During his years at Packard, he has been reponsible for many other contributions to the aircraft engine field and to automotive and marine engine design and advancement. These include such power plants as the Packard diesel aircraft engine for which Packard received the 1931 Collier Trophy and the Packard "Twin Six," America's first 12-cylinder automobile engine.

Colonel Vincent has always been interested in developing the young engineer. Many of today's top engineers spent their early tutelage under him. In effect, during the last 10 years, Colonel Vincent has been developing engineers as well as engines.

Aircraft Manufacturing Records

Two IAS Corporate Members—North American Aviation, Inc., and A. V. Roe Canada Limited—are listed in one of the National Safety Council's 1954 series of "Accident Rates" pamphlets as holding the aircraft industry records in their respective manufacturing fields. North American's Los Angeles plant is listed as having the aircraft manufacturing and assembly record of 5,608,573 injury-free man-hours. Avro is credited with the aircraft engines record of 1,410,761 injury-free man-hours.

The 1954 series of booklets on "Accident Rates" contains the 1953 accident experience of all companies that report to the National Safety Council and is published annually for each of 15 industries or groups of industries. The statistics on aircraft manufacturing and air-transport industries are contained in two different booklets.

Proceedings Available from Penn State

The Pennsylvania State University has announced that proceedings on the two short courses presented at Penn State last June are now available. The courses in question dealt with "High Temperature Properties of Materials" and "Mechanics of Creep."

The proceedings on the High Temperature Properties of Materials were prepared by Dr. C. Zener, Dr. B. J. Lazan, Dr. G. V. Smith, M. J. Manjoine, W. D. Manly, and D. R. Miller.

The proceedings on the Mechanics of Creep were prepared by Dr. J. E. Dorn, Dr. G. R. Irwin, Dr. L. F. Coffin, Prof. F. R. Shanley, G. D. Lubahn, and E. A. Davis.

Further information concerning these proceedings may be obtained by writing to Dr. Joseph Marin, Department of Engineering Mechanics, The Pennsylvania State University, State College, Pa.

Patent Advisory Committee Formed; Two IAS Members Named

Secretary of Commerce Sinclair Weeks recently announced the formation of an Advisory Committee on Application of Machines to Patent Office Operations. This committee was established for the purpose of finding new ways to speed up the processing of patent applications. The use of mechanical and electronic devices to facilitate patent searching is being considered.

Dr. Vannevar Bush, President of the Carnegie Institution of Washington, is the Chairman of the committee. Among the members appointed by Secretary Weeks to serve with Dr. Bush are two IAS members: Rear Adm. Luis de Florez, IAS Fellow and Founder Member, and Dr. A. V. Astin, IAS Honorary Member. Admiral de Florez is Chairman of the Board, The de Florez Company, Inc., and Dr. Astin is Director of the National Bureau of Standards.

The Right Honorable Clarence Decatur Howe *(left)* is shown receiving the Daniel Guggenheim Medal and accompanying scroll from J. Carlton Ward on last October 8 at the Society of Automotive Engineers' National Aeronautic Meeting in Los Angeles. Mr. Howe, Minister of Trade and Commerce and Minister of Defence Production, Canada, was awarded the Daniel Guggenheim Medal for 1954 for "initiating and organizing commercial air routes and services, promoting aeronautical research, development and production of aircraft and engines, and advancing the art of aeronautics." Mr. Ward, MIAS, is President of the Vitro Corporation of America.

Necrology

Eric Olsen

Eric Olsen, MIAS, Project Engineer, Naval Air Missile Test Center, Pt. Mugu, Calif., died on October 17. He was 58 years of age.

A native of Illinois, Mr. Olsen attended Columbia University as an undergraduate student. He entered Columbia in 1913 and was graduated from there 4 years later with a B.S. degree in Mechanical Engineering.

Between 1930 and 1937, Mr. Olsen worked with Universal Air Lines System and Waukesha Motors Company. In 1937, he opened his own field and research engineering firm known as Eric Olsen, Inc., Engineers. In 1943, after several years at the USAAF Hammer Field in Fresno, Calif., he was employed by Lockheed Aircraft Corporation first as Service Engineer and later as Maintenance Design Engineer (Consulting).

He was with The Wayne Pump Company in 1948 as Director of Research. Two years later, he was listed as the owner of Eric Olsen, Engineering Analysis. During 1951 and 1952, Mr. Olsen was Chief of Programs Unit, USAF, McClellan AFB, Calif., and Chief Research Engineer, Aircraft Conversion Engineering Company. In January of 1953, he opened the firm of Eric Olsen—Engineering Photography. He joined the NAMTC at Pt. Mugu last February.

Charles E. Richbourg

Charles Eugene Richbourg, TM-IAS, Engineering Test Pilot, Convair Division of General Dynamics Corporation, died on November 4 of injuries received while piloting the Convair-Navy YF2Y-1 Sea Dart.

Born on October 30, 1923, at St. Augustine, Fla., Mr. Richbourg attended Ketterlinus High School in St. Augustine (1937–1941), Aero Industries Technical Institute in Los Angeles (1941–1942), and Massachusetts Institute of Technology (1946–1951). Majoring in Aeronautical Engineering at M.I.T., he was granted an S.B. degree in 1950 and an S.M. degree in 1951. During his last year at M.I.T., he won the Henry Webb Salisbury Memorial Award for "outstanding work in the Department of Aeronautical Engineering."

In 1942, he went to work for Cook Engineering Company as an Aeronautical Draftsman. Enlisting in the U.S. Navy in June of 1943, he was trained as a naval aviator and served in this capacity until his discharge in August of 1946. Five years later, after completing his studies at M.I.T., he accepted the position that he held at the time of his death.

From February 4 until July 11, 1952, Mr. Richbourg was assigned as contractor pilot in Class 8 of the Test Pilot Training Division of the Naval Air Test Center, Patuxent River, Md. He was graduated from this course with honors, his standing being first in a class of 25 carefully selected military and civilian pilots.

News of Members

▸ **Dr. George P. Baker** (M), James J. Hill Professor of Transportation, Harvard Graduate School of Business Administration, has succeeded Frank C. Rathje as President of the Transportation Association of America.

▸ **Donald B. Brown, Jr.** (TM) is now on leave from Bell Aircraft Corporation and is working toward a Master's degree in Aeronautical Engineering at the Massachusetts Institute of Technology.

▸ **Victor E. Carbonara** (AF), President, Kollsman Instrument Corporation, Subsidiary of Standard Coil Products Company, Inc., has been appointed to Standard Coil's Board of Directors. Mr. Carbonara is an IAS Council member.

▸ **Lawrence A. Clousing** (AF), Assistant Chief, Full-Scale and Flight Research Division, Ames Aeronautical Laboratory, NACA, was selected to receive the University of Minnesota's Outstanding Achievement Award. The presentation was made at the October 15 dinner commemorating the twenty-fifth anniversary of the school's Department of Aeronautical Engineering.

▸ **Jacques Cornillon** (M), U.S., Technical Representative, Société Nationale de Constructions Aéronautiques du Sud-Ouest, has announced that on the occasion of the XXI Salon International de l'Aéronautique to be held in Paris, France, from June 12 to 19, 1955, the Association Française des Ingénieurs et Techniciens de l'Aéronautique will organize its traditional International Aeronautical Congress under the auspices of the Union Syndicale des Industries Aéronautiques. The Board of the AFITA has chosen "Aircraft Equipment" as the subject to be discussed by the Congress.

Dr. T. P. Wright, IAS Honorary Fellow, Vice-President for Research, Cornell University, has been appointed Professor of Air Transportation in the university's School of Business and Public Administration. Dr. Wright, who has been a member of the aeronautical profession since 1918, will conduct seminar work in air transportation.

▸ **Stanley J. Dzik** (AM), Chief Engineer of Corben Aircraft Company since last July, has been appointed Senior Staff Member of the Experimental Aircraft Association. Before joining Corben, Mr. Dzik was Senior Machine Design Engineer, Engineering Department, Globe Steel Tubes Company.

▸ **Dr. Antonio Ferri** (AF), Professor of Aerodynamics, Polytechnic Institute of Brooklyn, has been named Technical Editor of *Aero Digest*.

▸ **Donald D. Flickinger,** USAF (MC) (M), Director of Research, Headquarters, Air Research and Development Command, has been promoted to the temporary rank of Brigadier General, USAF.

▸ **Edwin A. Link, Jr.** (M), Chairman, Link Aviation, Inc., has been elected a Director of General Precision Equipment Corporation. Link Aviation is a subsidiary of General Precision.

▸ **Dr. William Prager** (AF), Professor of Applied Mechanics, Division of Engineering, Brown University, has been invited to give the 1955 James Clayton Lecture to the Institution of Mechanical Engineers, London, England, on January 14, 1955. He will speak on "The Theory of Plasticity: A Survey of Recent Achievements." While in Europe, Dr. Prager has been

(*Continued on page 60*)

Editorial

International Angles

As of the past few years, the activities of the IAS have taken a decidedly international turn. Although in the beginning the Institute drew heavily on the experience and advice of Britain's Royal Aeronautical Society and although in its earlier years Lester Gardner's travels abroad brought many distinguished European aeronautical scientists into honorary membership, the onset of the war and the events of the war years cut us off from most of our useful contacts in the international field.

This was a distinct loss to us, and it was recognized as such in the early postwar years. One of the first moves to restore relations abroad was undertaken in 1947 in the first joint conference with our colleagues of the Royal Aeronautical Society. That that experiment was successful is attested by the fact that four successful international meetings have been held, and a fifth is in the planning stages for June, 1955.

These meetings have brought us into increasingly close contact with our opposite numbers in Great Britain. The value of these meetings has come from both the erudite papers that have been prepared and discussed and from the less formal meetings over tea, beer, or a gin-and-French. We have come to be familiar with the dress, actions, speech, and general behavior of the British, and they with ours. This is good. It has led to a great deal of mutual respect and understanding. This, we hope, will continue.

Collaboration with our neighbors to the North imposed less of a strain on both sides, because the Canadians and ourselves are practically of the same piece of cloth. We very early learned to work together though our own Section activities in Toronto, Montreal, and

Ottawa, and, when they felt able to stand on their own feet organization-wise, we were pleased to aid and abet the founding of the Canadian Aeronautical Institute. Curiously enough, collaboration between the two separate Institutes will probably continue on a closer basis than it did when we were running a combined activity. This move also has provided a further basis for collaboration with the RAeS in London. The formation of the CAI followed conferences in London, Ottawa, and New York. We are jointly committed to promote the best interests of the new Canadian body. Cooperation—not competition—is the objective of all. As REVIEW readers are aware, the first Joint Conference between the CAI and the IAS in Montreal recently was a notable success and established useful precedent for the years ahead.

Of late, a new avenue of international cooperation has been opened to this Institute. At the invitation of Dr. Theodore von Kármán, AGARD Chairman, we have participated in various AGARD activities since the summer of 1953, when the Second General Assembly was held in London. In May, 1954, we took part in the Third General Assembly in Holland, and (as reported in the IAS News Notes, November REVIEW) the Director flew to Paris recently (courtesy of the USAF and MATS) as an observer at the meetings of the Documentation Committee.

The work of this Committee is particularly close to the Institute. The Aeronautical Reviews Section of this magazine is of great interest to all aeronautical organizations throughout the world. Our annual Aeronautical Engineering Index is a sought-after tool in libraries everywhere. As a first step in the establishment of a future international indexing and abstracting "pool" within the NATO nations, we are now supplying AGARD members with certain "raw" copy and proof sheets in advance of publication in the REVIEW.

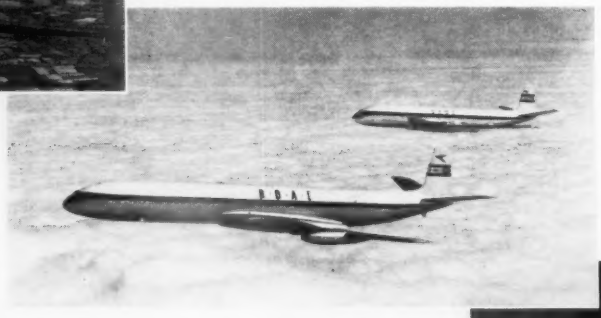
Dr. von Kármán in a recent letter said: "I believe an international abstracting service would secure a continuous and reliable flow of exchange of information at least in the unclassified field. . . . An international abstracting service would designate to the men interested in research and development what they should procure and read of the foreign literature. . . . It would be extremely valuable to friendly nations which have not the personnel or means for abstracting and reporting on everything that is going on in the world's literature. If the Institute could develop something in the direction of an international abstracting service, I believe you would make a great contribution to the aeronautical research and development in the United States as well as in the Free World."

Ideally, if each member nation prepared abstracts of its own current aeronautical literature and made them immediately available to a common pool, an international abstract bulletin would result which would be of great benefit. There are many problems to be solved (not the least of which is that of financial support for such an effort), but there would be no question of its value. We are now making a restudy of our abstracting capabilities, and staff changes are in process which, we hope, will lead to great improvement in servicing our members all over the world. What we plan to do will be geared to international requirements and will fit into the eventual ideal picture as envisaged by Dr. von Kármán.

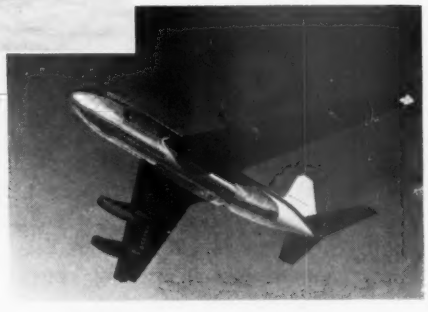
S.P.J.

Comet I (1949)

Left, Comet III (1954), and Comet II (1952)



Boeing 707 (1954)



The four types of commercial jets that have flown.

Instrumentation for Jet Transports

CHRISTOPHER DYKES*

Advising Aeronautical Engineer†

SUMMARY

Changes are likely to be found in instruments for jet transports to meet their particular characteristics. Their higher speed shortens the time scale and reduces the time for diagnosis of faults and for remedial action in flight, decreasing the need for visual indication but increasing the requirement for automatic recording. It also calls for coordinated instrument readings or, better still, computed instructions requiring little or no interpretation. For maximum economy, jet aircraft must be operated nearly at their limiting conditions demanding great precision in flying. The smaller operating margins and reduced flexibility alter the emphasis on crew duties. These factors are likely to result in more complex instruments, though weight and space may be saved by centralized computation. The principle of integrated flight systems may be extended to other instruments.

Specifically, the following changes may be expected:

The air-speed indicator will normally be the primary cruise control instrument and should be adapted to provide speed signals for autopilots. Direct measurement of outside air temperature is definitely required; when developed, it will permit calculation of true air speed without pressure measurement. In the meantime, measurement of true air speed requires improvements in Machmeters, which should also be developed to provide a signal at a preset Mach Number. There is a need for a completely new instrument registering ambient air temperature deviation. There is a requirement for an attitude or angle of attack indicator, preferably the latter. Autopilots require considerable further development to meet the special requirements of jet transports: there may well be a need to introduce the vernier control of engine speed. A general trend is probable toward types of attitude and orientation instruments coordinating more than one reading, particularly as director instruments computed from complex derivatives. Present types do not give all the required information, and the presentation can often be improved.

Gas temperature gages, which may become the most important single engine instrument, need to be more accurate and to respond faster. There may be a requirement for a control signal from rate of temperature rise. A radically new approach is needed in tachometer design without which the necessary accuracy will not be obtained. Engine governors will include many automatic safeguards, and accurate synchronization will be necessary. Thrustmeters will be required.

Fuel quantity gages are still not satisfactory. More accurate flowmeters are required, covering a wider range of different fuel conditions. Small recording accelerometers are required to assess structural fatigue There is an urgent need for good icing indicators capable of controlling the air-frame ice elimination system precisely.

The conditions under which automatic coupling is to be preferred to manual are discussed.

INTRODUCTION

ALTHOUGH AIRCRAFT DESIGN has been revolutionized in the last 15 years by new means of propulsion, we still rely on many instruments that are fundamentally the same as they were when first fitted to aircraft 45 years ago. With few exceptions, instrument development has until recently been generally oriented more toward refinement of existing designs—particularly toward greater accuracy and range and the removal of operating limitations—than in the direction of new types of instruments. The advent of the gas turbine required the development of new instruments, first, to measure the new quantities involved and,

* The author's thanks are due to Mr. Gabriel Giannini for permission to base this article on a study of the subject made for G. M. Giannini & Co., Inc., and also to friends in the industry for helpful comment.

† United Kingdom Adviser to G. M. Giannini & Co., Inc., and Director, Giannini Limited.

second, to meet the revised requirements for existing instruments. It is only in the last few years that there has been any tendency to develop completely new types of instruments. This need first became apparent for civil transports, but, apart from a brief discussion in the standard paper on "Civil Jet Operations" by Majendie,* the subject of instrumentation for jet aircraft does not appear to have been discussed in detail in any publication.

This article is written from the point of view of the air-line operator of jet transports, though many of the requirements are equally applicable to the military field. Although some 70,000 people have now traveled in one of the four types of commercial jets that have flown, it will be assumed that the reader has little or no knowledge of their operation, although he is generally familiar with piston transports. This survey, which is not intended to be exhaustive, therefore stresses the difference in instruments for jet transports from those fitted to present-day piston aircraft.

(1) General Considerations

Let us first consider the principal differences in the operation of jet transports as compared with piston transports.

The most striking change lies in the shortened time scale brought about by the jet's higher cruising speed. The extent to which this has multiplied the number of operational messages that must be handled by the crew in each hour of flight has not yet been generally appreciated in spite of an excellent paper on the subject by Campbell Orde.† Many consequences ensue. The crew has less time in which to diagnose any fault or to take remedial action: this decreases the need for visual indication of functioning but increases the requirement for automatic recording of data required for maintenance and overhaul. The shortened time scale also renders it desirable to present coordinated indications from more than one instrument. Carrying this one stage further, there is an urgent need to supply the crew with predigested data so as to remove as much of the load of interpretation of readings as possible, though this process must not be carried so far as to require a distinct set of instruments for monitoring.

The second major difference is that the most economical operating conditions with jet aircraft are much closer to limiting conditions than with piston aircraft, while the penalties for operating away from the optimum are higher. This demands a precision of flying to a previously unnecessary degree. The resultant fatigue on the human pilot is another reason for which automatic controls are likely to be adopted in greater number.

The third difference lies in the smaller margins that are economically necessary. Although it is certainly untrue to say that jet transports *must* be operated with less fuel reserve for stacking, and so on—for Comet and Viscount operations have shown that turbine aircraft can be fitted into existing traffic patterns—the premium that derives from such reduction is much greater than on piston aircraft. Combined with the generally lower flexibility inherently possessed by jet aircraft, this tends to concentrate the duties of the crew on the taking of operational decisions rather than on the mere handling of the aircraft and the engine controls.

From the mechanical point of view, the requirement for coordinated readings and for signals computed from them and their derivatives is bound to result in a great increase in complexity. Since signals for any particular function are now required for more than one instrument, weight and space will dictate a trend toward centralized computers into which signals derived from one source only for each function will be fed and from which all those required by each separate indicator will be obtained.

A number of integrated flight systems have already been proposed, combining and rearranging the indications of attitude and heading with direct and derived radio signals. It is probable that this principle will be extended to other groups of instruments. Since the function of this type of system is to present data from which the aircraft can be controlled more or less directly, it raises the issue of automatic versus direct coupling between these "black boxes" and the aircraft itself. This subject is discussed in Section (5).

(2) New Techniques Affecting Instrument Requirements

Perhaps the most interesting group of requirements arises from the operating techniques of jet transports. From an air-line point of view, the most important are those on which cruise control is based.

(2.1) *Cruise Control Instruments*

It is now recognized that, except in very unusual conditions, the flight plan will be invariant, having the characteristics shown in Fig. 1, as follows:

(i) Highest possible rate of climb so as to reach economical altitudes as quickly as possible.

(ii) Cruise at constant r.p.m., permitting the aircraft to climb at a steady rate of 30–40 ft. per min. as the weight is reduced.‡ A limit may be imposed by the maximum pressure differential.

(iii) Descent of the aircraft started at the moment when the cabin pressure is first allowed to increase up to ground level at the destination. Since the rate of this increase must not exceed that acceptable to passengers, there will usually be a minimum duration of descent. The minimum engine r.p.m. may be determined by the supply of essential services or, in some cases, by the flight idle stop necessary to avoid compressor stall, and it may therefore be necessary to use

* Majendie, A. M. A., *Civil Jet Operations*, Journal of the Royal Aeronautical Society, Vol. 57, pp. 539–555, September, 1953.

† Campbell Orde, A. C., *The Introduction of the Comet into Service*, Proceedings of the Fourth Anglo-American Aeronautical Conference 1953, pp. 265–288.

‡ Assuming it is not necessary to follow a stepped climb procedure to comply with air traffic control.

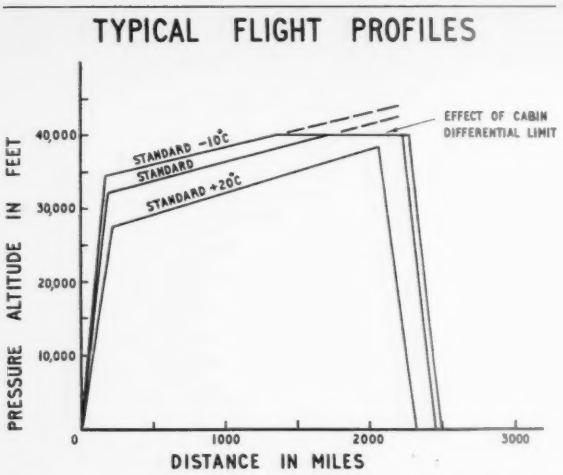


FIG. 1. Typical flight profiles for jet transports showing effect of nonstandard temperatures.

air brakes of one kind or another to avoid excessive Mach Numbers.

It will be observed that if the engine r.p.m. is held constant, then, for any given conditions of aircraft weight and outside air temperature, the operating conditions will be uniquely determined by any one of the four variables of Mach Number, indicated air speed, true air speed, and altitude. For cruise control, it is necessary to choose only one of these variables, the problem being to select that which shows the least change with conditions or disturbances—such as variations of temperature lapse rate, vertical air currents, and so on. A typical manner in which these four functions may vary throughout flight is given in Fig. 2.

(2.2) *Altitude*

The altitude normally varies throughout the cruising phase; moreover, Figs. 1 and 2 show that the optimum altitude for any particular weight depends on the air temperature. The altimeter, therefore, not only is unsuitable as the prime instrument for cruise control but can be dangerous, for if an attempt is made to reach a steadily increasing altitude as the aircraft flies into warmer air, the aircraft may stall or, at best, be uncomfortable to fly.

(2.3) *True Air Speed*

Most existing true air-speed meters seem insufficiently accurate or too bulky or unreliable for use as the primary cruise control instrument. There is a definite need for the development of a reliable and light true air-speed meter.

(2.4) *Mach Number*

While the Machmeter is now frequently used to calculate true air speed by combining its reading with the total air temperature, lack of resolution on present types normally prevents its use as a direct reference instrument. In any case, it is less suitable for cruise control than the air-speed indicator as its reading is more sensitive to temperature.

Since the margin between cruising and limiting Mach Numbers may eventually be less than on piston aircraft and may be no more than 0.05 M, so that a tolerance of ± 0.005 M is likely to be required in the cruising range—though a larger tolerance would be acceptable at the bottom end of the scale—it is highly desirable that the Machmeter should provide a signal at a preset value for the purpose of limiting any other signal to the autopilot as a safeguard in A.S.I.-controlled autopilots.

(2.5) *Indicated Air Speed*

The air speed indicator is generally used as the primary instrument for cruise control. On the whole, existing instruments are satisfactory, but the tolerance should not exceed 1 per cent under even the worst conditions, and a smaller figure is desirable. An increase in resolution is also required in view of the length of time required by a turbojet aircraft to settle down. (This arises from the constant thrust characteristic whereby there is less power available to restore any loss in speed from stabilized conditions than on turboprop or piston aircraft, which have substantially constant power characteristics.)

(2.6) *Incidence*

Several characteristics of jet aircraft combine to create a requirement for direct measurement of incidence. Although it does not at present appear that incidence meters could be relied upon to the 0.2° or so which would be necessary for them to be of real use in cruise control, readings to about 1° would be valuable in take-off and in landing. In the former case, sweepback renders it difficult to provide equally good stalling characteristics as on present medium-speed aircraft, and ground effect is more pronounced as there are no propellers beneath which clearance is required. The ground effect can allow the aircraft to be taken off in a semistalled condition and can also cause considerable float in landing, accentuating the difficulties already present due to the lack of windmilling propeller drag.

An incidence meter would also be of great use in maintaining a constant attitude through fluctuating conditions—e.g., turbulent air, varying temperature lapse rate, etc.

This explains the new requirement for sensitive indication of angle of attack. While instruments already exist for this purpose, they do not yet appear sufficiently robust for air-line use, and attention is turning toward an attitude indicator. A resolution of the order of 1° and a range of about 10° seem to be required.

(2.7) *Rate of Climb*

While rate of climb readings are unsuitable for cruise control because they are vitiated by a varying lapse rate condition, these instruments are likely to be retained,

at least for some time, as they give a useful indication of stabilized conditions. Existing instruments are satisfactory for this purpose.

(2.8) *Outside Air Temperature Deviation from Standard*

A particularly useful development would be a combination of temperature gage and altimeter giving the deviation from the standard temperature for that height. The outside air temperature normally varies throughout the cruising phase owing to the steady climb. Cruise control charts and tables based on outside air temperature are therefore complex. It is more convenient to use as the parameter the deviation from standard temperature as this varies only to a second order throughout flight (see Fig. 3). If the temperature lapse rate with altitude were to agree with the standard, the deviation would not vary at all throughout any flight in the troposphere, within which the majority of flights over the world's routes will take place for some years. (The tropopause can rise considerably above its standard height of 35,332 ft. in the NACA standard atmosphere, or 36,090 ft. in the International Standard Atmosphere, often reaching 60,000 ft. in the tropics; conversely, it may fall as low as 22,000 ft. over the Poles.)

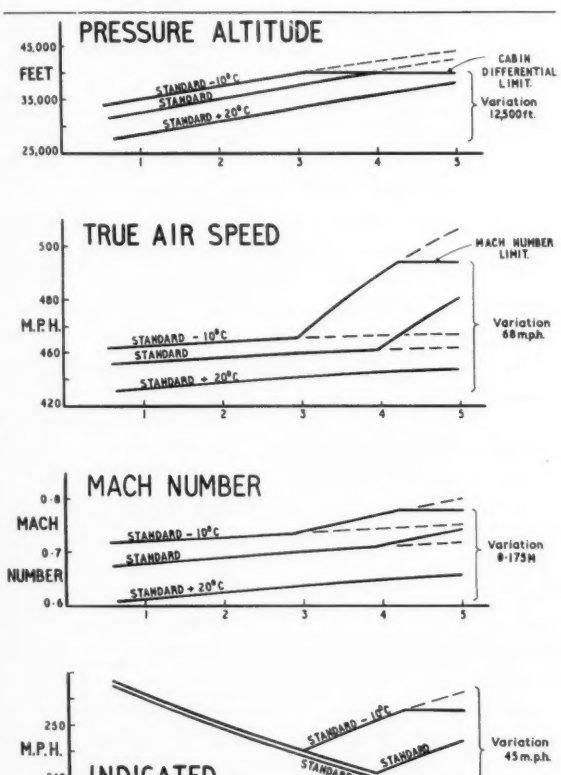


FIG. 2. Typical variation throughout a flight of the four principal parameters that could be considered for cruise control—pressure altitude, true air speed, Mach Number, and indicated air speed. Note that I.A.S. is the least sensitive to changes in temperature. The cruise control procedure shown is constant incidence.

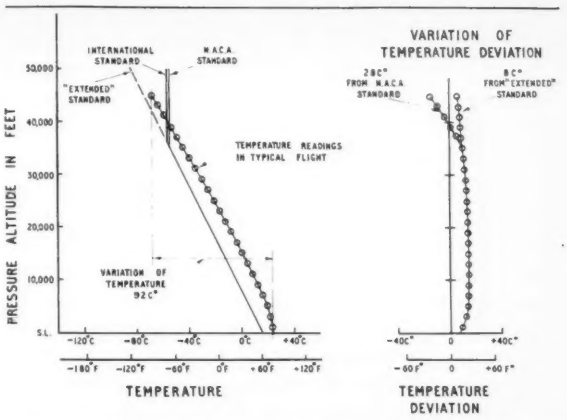


FIG. 3. Variation of temperature and temperature deviation during a typical flight. Note that variation of temperature deviation is less than that of temperature, rendering the former the more convenient parameter for cruise control. Note also the effect of an "extended" standard atmosphere in decreasing further the variation of temperature deviation during flights that pass through the level of the tropopause in the NACA and International Standard Atmospheres.

Because of the arbitrary definition of tropopause height, it has been found convenient to use an "extended atmosphere" in which the temperature continues to fall with increasing height without limit, as shown in Fig. 3. This proposal, incidentally, has the advantage of bringing the NACA atmosphere and the I.S.A. into line, although it might have to be abandoned when and if it becomes possible to cruise entirely within the stratosphere: even so, the concept would be useful in the climb.

(2.9) *Automatic Pilot*

A discussion of the requirements for automatic pilots for jet transports would require a separate article, but certain aspects deserve mention here:

(i) The margin between cruising and limiting Mach Numbers is small. Although the drag rise on present aircraft prevents the speed rising excessively in the event of any sudden nose-down movement of the aircraft, this may not be the case on future aircraft with thinner wings or more sweepback. It is therefore imperative that the elevator servo system of the automatic pilot truly should "fail safe." For this reason, magnetic amplifiers are attractive: a fairly high-frequency a.c. power supply may be desirable to decrease the time constants and also the weight of such equipment.

(ii) It will eventually be necessary to feed in automatically the signals needed to adhere to the selected cruise control procedure. At one time, it was suggested that suitable signals might be derived from an angle of attack instrument, but the necessary resolution was beyond available instruments. Not only the reading would be affected by movement of the c.g., but it would also be necessary to add a damping term, as even if the angle of attack is held constant, an aircraft can still sus-

tain a long-period oscillation—i.e., a phugoid, particularly when close to its minimum drag speed.

(iii) Jet transports are operated close to their absolute ceiling, and their performance is relatively sensitive to changes in c.g. position. Present automatic pilots refer their pitch gyros to aircraft axes and therefore try to maintain constant aircraft attitude. This further accentuates the effect of passenger movement or turbulence, requiring continual manual correction. The substitution of signals derived from the A.S.I. and not from attitude would effect a marked improvement, and some such automatic pilots have been flown, but a fundamental difficulty lies in the longer time required to recover stabilized conditions because of the constant thrust characteristic of turbojets referred to above. It is therefore suggested that the final answer might lie in the simultaneous vernier adjustment of engine r.p.m. through a fairly long time constant circuit so as to vary the thrust inversely according to a fractional power of the forward speed. The amount of such adjustment might have to be limited if overall economy is not to suffer.

(iv) A corresponding requirement exists for greater precision in azimuth. To match automatic coupling to pitch signals, the automatic pilot must be capable of accepting directional control signals from every radio aid to navigation, which must eventually provide definite lateral tracks, as the present system of quadrantal track separation is not possible with "drift up" cruise techniques.

These requirements can be met only by electronic types of automatic pilot.

(*2.10*) *Flight Recorders*

This increasing load on the pilot, both actual and latent, and the strong pressure to reduce the crew to a minimum—coupled with the higher rates of climb and descent which reduce the intervals at which readings must be taken for rectification of faults and for subsequent statistical analysis—are likely to result in flight recorders being fitted to all turbine aircraft. Requirements for other instruments will also be affected: eventually many secondary functions may be directly recorded from transducers without any indication to the crew, who, in any case, have less and less time to take corrective action.

The number of channels required is unlikely to be less than seven, even without duplication for each engine, if required:

Pressure altitude.
Air speed (either indicated or as Mach Number).
Outside air temperature (either total or outside).
Fuel flow.
Engine r.p.m.
Gas temperature (either jet pipe or turbine inlet).
Time.

It might be desirable to combine such an instrument with an accelerometer, though some of the objectives of the latter might be defeated by the laborious analysis required.

(3) Instruments Not Found on Piston Transports

Two new instruments arise from the nature of turbines as power plants:

(*3.1*) *Gas Temperature*

(While the jet pipe temperature is measured on most British engines, the standard American practice has been to measure turbine inlet temperature. From the point of view of instrument requirements, the difference is immaterial and need not concern us here, though the resultant range is, of course, different.)

It is well known that maximum gas temperature is, perhaps, the most important limitation that must be observed. Although many present instruments are designed with a tolerance of ±10°C., this is not always maintained, and errors of as much as 30°C. are not uncommon in service, rendering it necessary to throttle an engine on take-off because of excessive reading. Gage inaccuracy therefore has a direct effect upon safety: either a definite risk is being run of exceeding safe turbine blade temperatures on a number of occasions, thus affecting engine reliability, or if the stated limits are reduced accordingly, power is unnecessarily decreased, thus causing a reduction in economy because of the thermodynamics of the gas cycle and hazarding obstacle clearance at take-off, or, alternatively, reducing the permissible take-off weight. Both the sensing device and the gage itself must therefore have high accuracy and high resolution.

Even if temperatures outside the normal cruising range, below, say, 400°C., were suppressed to secure a wider scale—which might be difficult to accomplish accurately without close voltage regulation of the aircraft power supply—it would not improve the intrinsic accuracy of the instrument. Moreover, it would prevent the use of the instrument in starting when the rate of increase of gas temperature is a good indication of the engine lighting up. (It is not possible to use a simple device measuring the difference between gas and air temperatures for this purpose, as it may be necessary to restart an engine while it is still hot.)

An important requirement for gas temperature gages is a rapid response. The air intake can ice up in flight with startling rapidity because of the high rates of air flow. When the air flow is suddenly decreased, excessive gas temperatures can be reached very quickly; in fact, the gas temperature gage is probably the best indication of engine icing in cruising.*

This rapid response is desirable over the whole range, including starting when the permissible turbine blade temperature can be exceeded in a very short time owing to the small air flow. A rapid rate of response may not be enough by itself, however, as the crew may fail to observe the indication sufficiently soon. It may therefore be necessary to provide a signal to operate a warn-

* Though this does not remove the need for an icing indicator, as the engines can ice up under other conditions without any indication on this gage—e.g., when throttled back in descent. If the throttles are then opened, serious damage can result.

ing mechanism or, better still, to override the fuel control, decreasing the flow instantaneously in the event of a sudden rise of temperature.

In future installations, the gas temperature gage may become the most important engine control instrument. If, and when, maximum r.p.m. limits are made variable with ambient air temperature, this instrument might be the only practicable means for setting limits.

(3.2) *Thrust*

Some form of thrust measuring device is definitely required on jet transports as a means of checking engine performance. Although it appears that the performance can be fully restored after overhaul if careful attention is paid to certain details, experience has shown that the thrust decreases sufficiently between overhauls to cause a considerable reduction of the rated take-off performance of any particular aircraft. Thrustmeters will be particularly useful on aircraft with buried engine installations that show virtually no swing if an engine fails on take-off. It is difficult to tell when an engine fails to give full thrust for any reason, and special co-pilot techniques are needed at take-off.

The value of mechanical thrustmeters measuring fore-and-aft trunnion loads will be limited to some extent by the unknown air intake and jet pipe losses, although they would be useful as comparative instruments. Net propulsive thrust has been measured from intake and jet pipe pressures but substantial corrections are necessary for intake and jet pipe areas and discharge coefficients.

A third new instrument arises from the greater operating altitudes and speeds:

(3.3) *Vertical Acceleration*

An important requirement has arisen for instruments to record vertical accelerations and so to determine the eventual life of the air frame more accurately rather than imposing some arbitrary and conservative limit. The wealth of operating experience on unpressurized aircraft at 10,000 ft. and below now permits a tolerable assessment of maximum life to be made from relatively few structural tests. It is possible even to vary the life according to the operating conditions—e.g., a total life of 15,000 hours in the United States might be reduced to 6,000–8,000 hours in areas where flights at these altitudes are seldom free from turbulence even in the cool of the day or at night, as in Rhodesia or Central Australia.

A fair amount of data have been secured from pressurized aircraft cruising up to 25,000 ft., but the amount on turbine aircraft cruising at 30,000 ft. or above is statistically negligible. In order to state component lives, it will therefore be necessary to fit some type of accelerometer recording not only the number and magnitude of the gusts of the highest magnitude but also the large number of moderate gusts, which cause the greatest reduction in air-frame life.

American thought seems to be toward the simultaneous measurement of acceleration, altitude, and air speed. In the United Kingdom it has been held that while these readings are most useful for research purposes, the conditions under which transports will be operated are relatively so constant that the number and magnitude of the accelerations are a sufficient measure of damage; but this view may alter.

(3.4) *Air-Frame Icing Indication*

Although air-frame icing does not require such instantaneous corrective action as turbine icing, it can have a serious effect on economy. The heat required is usually obtained from compressor or turbine bleed: this increases the specific fuel consumption by a large amount and the loss of power causes a reduction in altitude and hence a further rise in specific consumption.

It follows that mere indication of air-frame icing will not be enough: the instrument must record the severity of the icing conditions and be capable of controlling the ice-elimination system accordingly.

(4) Revised Requirements for Existing Instruments

The reader may be surprised at the extent to which some of the instruments used on piston transports have to be modified not merely with respect to scale reading but in the direction of increased accuracy.

(4.1) *Engine Speed*

Gas turbines have a characteristically rapid rise of specific consumption with decrease in r.p.m., the effect usually outweighing any reduction in power required at a lower forward speed, so that present aircraft turbines, particularly turbojets, always run at the highest engine speed consistent with reliability and good overhaul life. The cruising r.p.m. range is quite narrow, only 5 per cent of maximum r.p.m. being common, and this may even decrease on some of the newer compound turbines now emerging. It might therefore be considered that an expanded scale should be provided merely to cover the cruising range. In actual practice, however, readings in the idling range are required when starting, the sudden increase of acceleration being a useful indication of a successful start. It is also important to observe whether the engine has reached the minimum self-sustaining speed in the event of a marginal start—i.e., when the starting system is below par for some reason or another—or whether the start should be abandoned.

Variation in engine speed has a greater effect on the power of a turboprop than of a piston engine, and there is an even greater effect on the thrust of a turbojet. The following figures clearly show the requirement for higher tachometer accuracy:

Typical piston aircraft: 1 per cent change in r.p.m. corresponds to $^3/_4$ per cent in aircraft speed.

Typical turboprop aircraft: 1 per cent change in r.p.m. corresponds to $1^1/_2$ per cent in aircraft speed.

Typical turbojet aircraft: 1 per cent change in r.p.m. corresponds to 4 per cent in aircraft speed.

It might be feasible to employ a highly stable electronic oscillator for a reference frequency and to measure only the difference between that frequency and that derived from the engine in question. This would give a high degree of accuracy where it was most required and would offer attractive possibilities for synchronization.

Hitherto, the tachometer generator has usually been driven off an accessory drive. This prevents the tachometer giving an immediate indication of certain types of engine failure—e.g., of a turbine shaft. It may be desirable to provide a more direct drive from the turbine itself on future engines.*

It might be observed that the new "percentage" scales seem an obvious improvement on the earlier types indicating actual r.p.m.

(4.2) *Fuel Flow*

Although fuel flow has for a long time been outside the pilot's direct control on jet aircraft, measurement of fuel flow is, nevertheless, a primary function, as the rate of reduction of aircraft weight is the most important single factor in flight progressing. Flowmeters also have two secondary uses: first, to indicate the correct functioning of the engine—the indicated value being compared against charts for the corresponding r.p.m., intake temperature, and pressure altitude; and, second, to indicate certain types of malfunctioning.

Basically, gas turbines behave as ground-level-supercharged engines and the fuel flow decreases continuously above sea level, frequently in a ratio of 4:1 or more (except on certain new turboprops, where the maximum power may be limited below a certain altitude, yielding a characteristic similar to supercharged piston engines, with certain other benefits). Flowmeters must therefore cover a fairly wide range, preferably including the starting range where they give a useful indication of the functioning of the fuel pumps.

The accuracy required is not unreasonable, ±1 per cent appearing acceptable and ±½ per cent being desirable: a constant percentage tolerance is better than a fixed tolerance. This must be maintained under all conditions of fuel temperature and specific gravity, the former being a major difficulty owing to the wide range of outside air temperatures. The instrument must also be protected against blockage by ice crystals. Owing to the long duration at low temperatures possible on transport aircraft, a percentage of water, which can remain in solution on fighter aircraft, crystallizes out.

(4.3) *Synchronization*

Although it was wishfully hoped that the low vibration level on turbines might render accurate synchronization unnecessary on multiengined aircraft, this property has actually intensified the requirement because lack of synchronization is all the more noticeable. Automatic synchronization, which is already useful on piston transports, becomes a necessity on all forms of turbine transports, particularly turboprops.

It can be achieved in many ways and with an astonishing accuracy. At least one pattern of British engine speed governor has been adapted to maintain two turbines running at just under 10,000 r.p.m. within 45° in phase, the limit being imposed merely by the length of fuel in the pipes and the sensitivity of the fuel metering system. The problem is, in fact, a cybernetic one of improving the characteristics of the engine control.

(4.4) *Air Temperature*

Outside air temperature is an important parameter on every aircraft but is relatively more so on turbine aircraft because of the increased temperature sensitivity of turbines. For instance, a change of 1°C. on the Comet Series I results in a variation of 180 ft. in cruising height, 1 knot in cruising speed, and 50–75 lbs. in fuel used in climb to the cruising height. On transatlantic jet transports, a change of only 2°C. will be equivalent to the weight of one passenger. This means that fuel reserves may have to be carried to provide against errors in forecasts of air temperature as well as headwind component. It can be appreciated why accurate forecasting of air temperatures will be essential for the economical operation of such aircraft.

Present air temperature gages record not ambient temperature but total temperature—i.e., ambient plus ram temperature. With careful installation, the temperature recovery factor is generally near unity, so that at 550 m.p.h. the difference between the two temperatures is 30°C. Temperature correction does not appear to vary significantly among individual aircraft of one type, so that there is no valid objection to a high correction: nevertheless, a gage reading ambient air temperature directly would find a wide market. It would also open up an entirely new possibility in the measurement of true air speed, for the difference between the reading of the total air temperature gage and the new gage would yield true air speed directly without any pressure measurement. At 500 m.p.h. this difference need only be measured to ½°C. to give the true air speed within 1 per cent, and the accuracy will increase as the speed increases.

Incidentally, since this difference is also related directly to Mach Number, it could eliminate the Machmeter, though it is not easy to visualize a suitable presentation.

(4.5) *Fuel Quantity*

Fuel quantity gages not only are primary instruments in that failure could jeopardize the safety of the flight but are of major importance in cruise control, as it is from them or from integrating flowmeters that the instantaneous cruise weight must be determined.

* This will become even more important with certain configurations of turboprop engines. The great attention now being paid in Britain and the United States to the consequential dangers of turboprop failure is proof that they are clearly recognized. No-torque indications from reduction gear torquemeters and excessive rate of change signals from gas temperature gages and tachometers should provide sufficient safeguards.

The weight of fuel on a jet transport may be several times greater than the pay load so that fuel reserves to cater for fuel gage errors are more expensive than on piston aircraft, though to some extent they are self-adjusting as an error in fuel weight will cause a corresponding change in consumption in the same direction. Nevertheless, any error is bound to affect either safety or economy. Existing instruments have a tolerance substantially constant over the whole scale, whereas, from the flight progressing point of view, the tolerance should be tightest when the tanks are nearly full and also when they are nearly empty: the present tolerances of about $2^1/_2$ per cent of the gross capacity are excessive.

It goes without saying that the fuel quantity gages should be calibrated in terms of mass. The error in using standard densities for high-octane gasoline or for aviation kerosene is about ± 3 per cent, and there is a greater spread on wide-cut gasoline. Automatic correction for density would seem to be well worth while in reducing the fuel reserve that must otherwise be carried.

Several new types have recently been announced claiming accurate compensation for density and independence from aircraft attitude. It is also convenient if the gages need not be matched to particular tank elements so that corresponding gages on the two sides of the aircraft can be reversed to check the gages and units in flight.

Perhaps the most important point is that the design of the fuel system is at least as large a factor as gage and tank element accuracy in determining the overall performance: both must be given equal consideration, preferably at an early stage in the aircraft design.

(4.6) *Attitude and Orientation Instruments*

Requirements for attitude and orientation instruments are not directly affected by the type of power plant, but the higher cruising speed and the need for greater precision to achieve lower margins have been responsible for the enthusiastic acceptance of director instruments, which provide instructions as to the manner in which the aircraft controls should be moved in order that the aircraft should follow a desired flight path or pattern. Director instruments differ from earlier attitude and orientation instruments that generally indicated displacement from the desired flight path and therefore required the pilot to interpret the readings from several instruments in order to estimate the correct movement of the controls, which he usually did in a series of successive approximations.

This is not the place to discuss these instruments, but it should be emphasized that they do not in themselves provide all the answers required, for none of those so far announced indicates the *progress* along the desired flight path or the instantaneous attitude reached.

With regard to attitude and orientation instruments generally, it is worth pointing out that there is room for further improvement in presentation, particularly for use when visual references are concealed. At one time it appeared that the approach was toward the simulation of these visual indications as closely as possible—e.g., the artificial horizon replacing the visual horizon. Unfortunately, however, this trend died out. Some instrument presentations have borne little relation to what would be seen by the eye under clear conditions, although certain recently announced flight systems that show great promise notably fulfill this condition. In so doing, at least one of these new systems permits the same instruments and displays to be used under manual coupling, with or without directors, as under fully automatic coupling to an automatic pilot.

(5) Automaticity Versus Manual Control

The problem of automatic versus manual coupling between the instruments themselves and the controls that must be operated is burning and perennial. Taking the wider issue of automaticity versus manual control, it is obvious that the best compromise will depend upon circumstances and that there will be no unique solution. The question has great importance for turbine transports because the premium for refinements in technique is greater there, and automatic controls can be made to perform repetitive routine tasks much better than human pilots.

At first sight, the compromise appears to be a purely economical balance between the first cost, additional maintenance, overhaul and operating costs, and the weight and space required and a conservative estimate of the yield through increased efficiency. However, this ignores the frequency with which automatic devices fail: even though emergency manual controls are fitted, there is a considerable increase in the latent causes of pilot fatigue, and the net result can be a reduction in real safety.

Generally speaking, automatic coupling or an automatic device would appear to be justified under three conditions:

(a) If it can perform a function that cannot be done by a human pilot; this applies to most instruments.

(b) If without it, the load of work on the pilot would be sufficiently heavy to cause marked deterioration of performance under some conditions.

Whether either of these two conditions applies in any case is usually self-evident, but the third is a matter of judgment:

(c) If it can give a justifiably superior performance than the human pilot.

It may be interesting to summarize the conditions under which a machine can outperform a human, which may be stated as follows:

(*i*) *Faster response and shorter lag:* leading to more accurate control under disturbed conditions. This is the case for automatic fuel flow controls and for automatic pilots.

(*ii*) *Smoother response:* because a machine can be constructed to respond to any desired derivative or combination of derivatives—e.g., rate, acceleration, $(\theta + \dot{\theta})$, etc., and with any desired degree of feedback,

thus eliminating hunting. This is the case for computed approach control.

(*iii*) *Ability to control greater powers directly:* i.e., a servo can be built in without further presentation and interpretation of data.

(*iv*) *Less chance of error in simple repetitive jobs:* this is the case for automatic positioning devices.

(*v*) *Perfect watchfulness and no fatigue:* a machine in working order cannot be caught napping. This is the case for automatic limiting devices.

(*vi*) *Better short-term memory:* which has been used in one interesting application to provide steady readings of a radio navigation aid under conditions of serious static and fading.

(*vii*) *Vastly superior computing ability:* the most striking improvement of machine over man. This is a consequence of its intrinsically higher deductive ability.

On the other hand, expensive mechanical and electrical developments are unlikely to be warranted when any of the following are required:

(*i*) *Wide range of input signals:* all the human senses —the eye, the ear, etc.—are amazingly tolerant of wide variations in level.

(*ii*) *Overloads:* a man will usually retain some degree of success under overload; most machines will either succeed 100 per cent or break down completely.

(*iii*) *Improvization:* when a completely new combination of adverse circumstances is likely to occur.

(*iv*) *Judgment:* when a choice has to be made on the basis of incomplete information or intangibles.

(*v*) *Long-term memory:* above all, the ability to select the desired information from past impressions.

(*vi*) *Inductive reasoning:* perhaps the ultimate achievement of man over machine.

(6) An Approach

The above may lead the reader to conclude that radically new approaches are necessary in some cases if the requirements are to be met. A single example of the possibilities will suffice.

The tolerance of existing tachometers of ±1 per cent is easily surpassed on one of the cheapest forms of precision instrument—a clock. A tolerance of this amount would only involve timekeeping within 14 min. a day: cheap watches do ten times as well, and the best clocks enormously better. While it is not suggested that a chronometric approach to tachometers would necessarily be correct—in fact, such instruments have been built, but their accuracies are of the same order as existing electrical types—and even allowing for the fact that a timekeeper is essentially a single-speed device, the accuracy of present tachometers is regrettably low.

(7) Conclusion

A turbine transport is essentially a precision machine, capable of giving a superior result over a smaller range of conditions than a piston aircraft. In order to achieve the full economy of which it is capable, it must be operated with relatively smaller margins of fuel reserve and with greater precision. Any inaccuracy in primary instruments will therefore affect the safety or economy of jet transports to a greater degree than at present because the reduction of operating margin or, alternatively, of the extra reserve required is a larger proportion of the available margin or reserve. Advanced instruments will be fully justified if they have a better performance or improved accuracy.

Now Available

Proceedings of the National Turbine-Powered Air Transportation Meeting

Seattle, Wash.—August 9–11, 1954

Contains all 14 papers presented at this meeting, complete with figures and illustrations.

Member Price, $3.50 Nonmember Price, $6.00

Copies may be obtained by writing to:

Publications Department
Institute of the Aeronautical Sciences, Inc.
2 East 64th Street
New York 21, N.Y.

Control Stick Steering for Stabilized Aircraft

BEN H. CISCEL*

Minneapolis-Honeywell Regulator Company

Introduction

As automatic stabilization becomes more and more a basic requirement for aircraft, the problem of maneuvering the stabilized airplane becomes of major importance. This paper begins with a discussion of some of the earlier means, shows their inadequacies, and leads up to a comparison of modern methods. It is apparent that our demands upon automatic equipment (for inhabited aircraft) are becoming more sophisticated, as well as more exacting in terms of speed of responses and damping.

An outgrowth of these demands for more natural flight is the autopilot technique called control stick steering.

Since one of the primary objectives of modern autopilot development is to provide autopilot maneuvering through use of the manual stick, this matter has received considerable attention. As is true of all engineering advances, there are times when complications and compromises have to be balanced against the advantages of a particular system. Out of many possible ways, five of the most promising mechanizations of control stick steering are discussed and compared.

For the sake of consistency, the schematics of various types of control stick steering will be superimposed upon the simplified aircraft control system diagrammed in Fig. 1.

(I) Turn Control Knob

The concept of the "relief autopilot" was exactly as the name implied—a system to allow the human pilot to do other things while the autopilot "held the airplane still" for him. However, relief autopilots lead an uneasy life since people are always thinking of more jobs for them.

The early autopilots had means for adjustment and trimming, serving as much to make up for the vagaries of the equipment as to take care of the trim needs of the airplane. It was a natural extension of the existing knobs to add another for turning. As time went by, the other adjustments were reduced in number (or hidden from the pilot), and the configuration of the pilot's control panel became settled to a grouping of trim knobs and a turn knob.

The turn knob is usually larger and boasts a more prominent location on the panel. (See Fig. 2.) Maneuvering is accomplished by rotating the knob in the direction one wishes to turn. In most automatic pilots, turning the knob disconnects the heading control system and produces a bank angle (or turning rate) proportional to knob deflection. Ordinarily there is no "feel" to the knob, except some kind of detent that indicates the zero bank, or inactive, position. When the turn knob is returned to the detent position, turning stops and the new heading is engaged.

Considered critically, the turn knob has little to recommend it; and yet it has been (and is) consistently popular with pilots. Perhaps the secret of its success lies in the fact that it is so simple and does not pretend to imitate the control motions the pilot makes to accomplish a turn on the regular aircraft control system. However, it is limited to the lateral axis only, and this is not sufficient for maneuvering military aircraft.

(II) The Formation Stick

A second development was a true maneuvering controller, or formation stick, shown schematically in Fig. 3. The 1943 version of this device (Fig. 4) was a small knob driving a couple of signal potentiometers. The knob was spring-centered and could be moved laterally for turns and longitudinally for climbing or diving. This first stick was small, lightweight, and simple. It was an immediate success but was soon found to need a few small improvements: just a little more travel of the stick to cut down control sensitivity, perhaps springs a bit stiffer for better feel, and possibly a little damping. And that little knob—could it accommodate a microphone button and a few other switches? Come to think of it, why not use a standard pistol grip like that of the regular control stick?

With the resulting new pistol grip, the pilot found he had a firm hold and the springs did not seem stiff anymore. Consequently, he could exert so much force that the whole device had to be "beefed up." Fig. 5 shows the 1952 version of the formation stick. It was mechanized not merely to suit someone's aesthetic sensibilities or a production engineer's dream; no it was tailor-made for the user—the human pilot.

In addition to providing natural control motions, this stick has another advantage—a known relationship between the servos and the stick position—that is, when the formation stick is centered, the servos should not make wide excursions. If they do, the autopilot is automatically disengaged. If the servo goes the wrong way when the stick is placed to command a given turn, again disengagement occurs. All this is done with reliable switches and results in a great improvement in safety over that of an autopilot with no limits of travel or torque.

The formation stick has had wide application, in fighters, bombers, and helicopters. However, it suffers from many disadvantages:

* Project Engineer, Autopilot Section, Aeronautical Division.

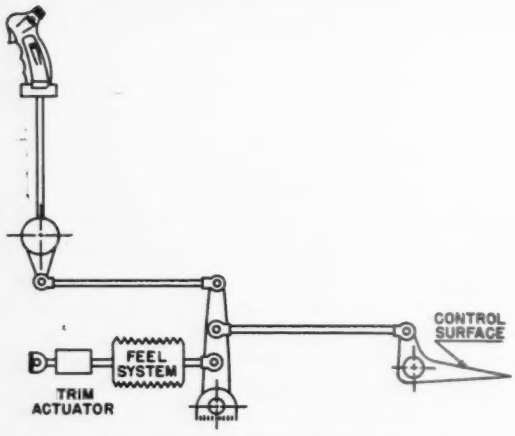


FIG. 1. Schematic—simplified aircraft control system.

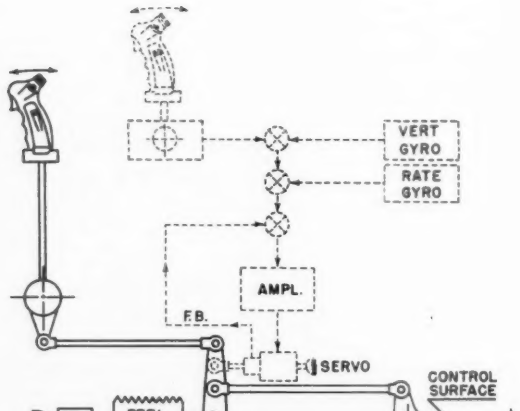


FIG. 3. Schematic—"formation stick" maneuvering controller.

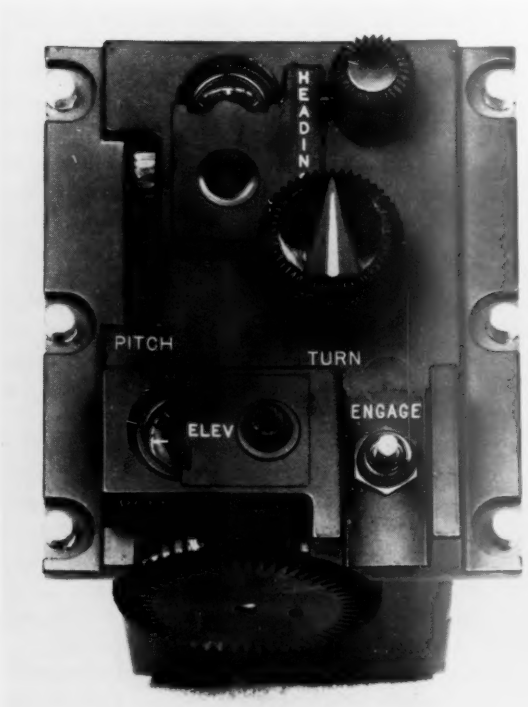


FIG. 2. Typical flight controller.

FIG. 4. Formation stick, 1943 version.

(1) The controller is difficult to locate, both from the standpoint of space required and accessibility to the pilots.

(2) The "feel" of the little stick is different from that of regular controls, both in radius and force.

(3) The "action" of the little stick is different from that of regular controls in that stick position corresponds to an angle of bank or pitch rather than a rate of motion.

(4) In case of an emergency, the human pilot must decide when to leave one control and go to another.

(5) In unstable aircraft, the motions of the regular controls are a distraction to the human pilot, since they do not move exactly the same as the formation stick.

For these reasons, it appears that the procurement of formation stick autopilots has come to an end in American military aircraft.

(III) Differential Servo System

Use of the autopilot servo as a differential (or variable-length) link is attractive for several reasons. Among them are: (1) manual input is possible directly through the pilot's controls; (2) "overpowering" of the autopilot is easily accomplished; and (3) autopilot stabilizing motions are absent from the control stick. The disadvantages of this system arise mainly in steady-state stick trim, control authority, and engage-disengage problems.

A differential system suitable for the pitch and roll axes is shown in Fig. 6. To illustrate how it operates, let us consider a steady bank maneuver. The pilot moves his stick laterally in the usual manner, the motion transmitted directly to the control surfaces. Meanwhile, a signal pickoff on the pilot's stick ensures that the autopilot will aid rather than resist the maneuver. At the desired bank angle, the pilot eases off his stick force, and the autopilot gyros damp and hold the bank angle. While holding the bank, the pilot will notice that his stick is somewhat off center in the direction of the bank. This is because the signal pickoff voltage is needed to balance the vertical gyro signal. Pitch operation is generally similar.

In early differential servo applications, it was assumed that the authority (or percentage of total travel) would be low. In the case of an autopilot malfunction, the human pilot would merely "overtravel" the autopilot. However, pilot comment indicated that the reduction of control in either direction, even as low as 20 per cent, would be unacceptable. Therefore, the accent shifted to servos with recentering devices to center them automatically in case of malfunction or disengagement. It is obvious that the degree of reliability of these recentering devices must increase as the authority of the autopilot increases. An example of the differential type of hydraulic servo is shown in Fig. 7.

To summarize, the differential servo arrangement has come into widespread use, for both autopilot and damping functions. Full automatic control with the differential servo arrangement poses the following problems:

(1) A suitable compromise between the low authority desired for safety and the high authority required for full maneuverability.

(2) The need for automatic trim, especially in pitch.

(3) The fact that the stabilizing control motions do not appear at the stick, depriving the human pilot of an extremely important index of how things are going.

Major reasons for the continued use of the differential system are:

(1) It does not change the feel of the airplane but does permit an improvement in response characteristics.

(2) Safety is derived from a limited servo authority.

(3) It is relatively simple to vary the travel limits of the servo, if needed.

(IV) Force-Stick

Shown in Fig. 8 is an arrangement that balances pilot force against rate of motion. The forces are usually comparable to those of the basic airplane, and the resulting feel is quite natural.

This system, successfully flown in several aircraft, uses stick force to control the automatic pilot. The manual stick has a resilient member (designed for reasonable stiffness and limited relative bending) which produces an autopilot signal proportional to, and in the direction of, the pilot's push or pull. Fig. 9 shows a stick-force transducer of this type. If desired, this force signal can be fed directly into the autopilot to drive the servos. Fig. 10 shows a parallel hydraulic servo.

In addition, an integrator is usually required which runs as a function of the force signal to balance the signals from the vertical gyro. Let us again illustrate with the bank maneuver. The pilot exerts lateral force on the stick, and the autopilot servo runs in the same direction. The integrator builds up a voltage to balance the bank angle. The pilot eases off as he approaches the desired bank angle, and the autopilot will hold the bank angle, stick centered, hands off.

The integrators (not shown in the simplified Fig. 8) represent a complication over and above the conventional autopilot. They are often composed of an amplifier, motor, gear train, and signal device. However, they will also serve for synchronizers. (Synchronization is a term applied to the automatic process of adjusting the disengaged autopilot in accordance with existing flight conditions so that there will be no "bump" upon engagement.)

One of the unknowns in the application of this system to each new aircraft is the effect of stabilizing motions on the manual stick. Since this is a parallel servo system, the stick follows every correction. Thus, for each new application, it is not known if (1) the pilots will accept the accompanying feel, (2) the resulting force signals will negate the stabilizing influence of the autopilot, or (3) these motions will result in a system that is difficult to trim through the stick force. It

FIG. 5. Formation stick, 1952 version.

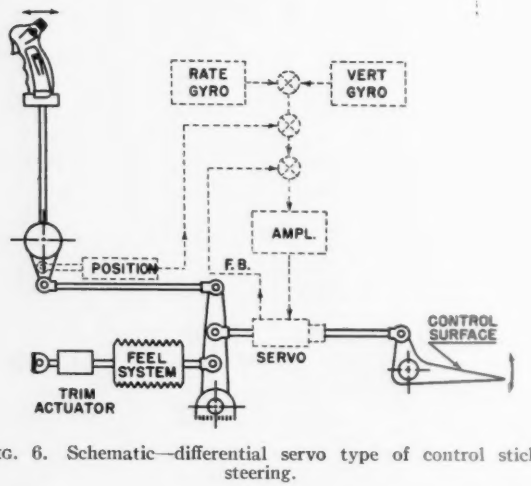


FIG. 6. Schematic—differential servo type of control stick steering.

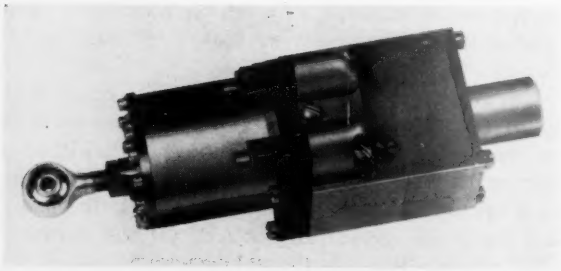


FIG. 7. Typical differential servo (hydraulic).

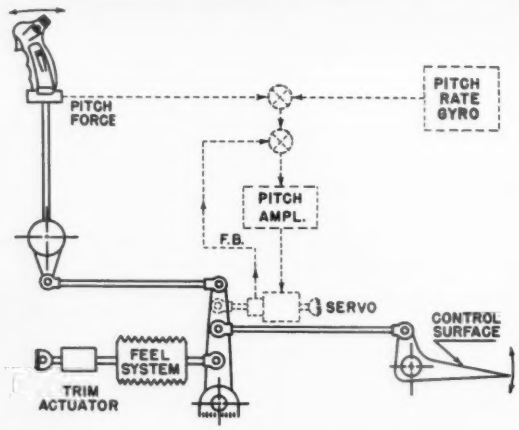


FIG. 8. Schematic—force-stick type of control stick steering.

FIG. 9. Stick-force transducer.

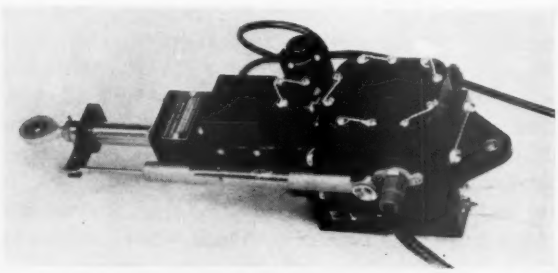


FIG. 10. Parallel hydraulic servo, early version.

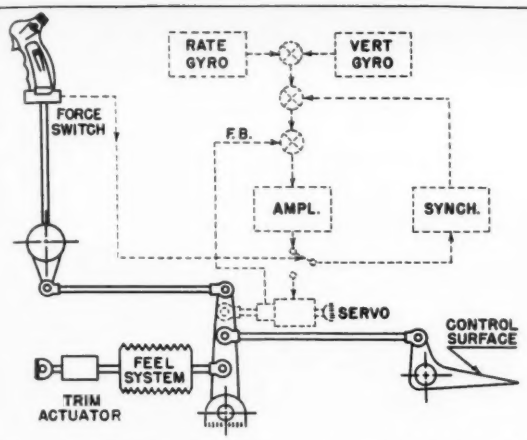


FIG. 11. Schematic—disengage type of control stick steering.

would, of course, be possible to put rate signals through a separate differential servo in each axis, but this definitely results in a more complicated system.

The advantages of this force-stick system are:

(1) Good feel to the human pilot.

(2) Airplane is always flown stabilized.

(3) The pilot's stick position always corresponds to the surface position.

(4) Servo force limiting can be used for safety and ease of overpowering.

The disadvantages include:

(1) The feel, though good, may be different from that of the free airplane.

(2) In turbulent air, stabilizing motions appearing on the stick may annoy the pilot.

(V) Disengage System

Shown in Fig. 11 is a system that has been flown in two forms. One operates exactly as shown, with application of pilot force to the control stick causing disengage of the automatic pilot. The autopilot stays disengaged while the human pilot is maneuvering, so that his "feel" is that of the airplane. When the human pilot stops maneuvering, the automatic pilot reengages and stabilizes the airplane in whatever attitude the human pilot has left it.

The second variation of the system shown in Fig. 11 differs only in the manner of initiating the disengage. Instead of a force switch, a push-button switch on the stick is used. The things make this undesirable: (1) there are already too many switches on the stick in most military aircraft; and (2) pilots are likely to forget the button and start maneuvering by overpowering the autopilot. When the forces they encounter are unusual enough to remind them that they have forgotten something, they push the button and somewhat of a transient results as the autopilot disengages.

The major advantage of the disengage type of control stick steering is that the feel of the airplane is not changed for maneuvering. Unfortunately, the stability is not changed either, unless some auxiliary damping system is used in addition to that shown in Fig. 11. Another disadvantage is the difficulty of making perfectly smooth all the transitions from stabilized flight to disengaged flight—that is, there are almost always little bumps and jerks associated with the disengage and re-engage. Automatic trim for the elevator must be nearly perfect to eliminate force transients. Since pilots are extremely critical of these transients in the stick, many of them have expressed preference for a system like the force type, which changes the feel somewhat but always stays engaged.

(VI) Electric Stick

The electric stick system is a scheme that has been suggested many times but to our knowledge has not yet been accepted in any production aircraft. As shown schematically in Fig. 12, the pilot's controls move signal devices only. The actual controls are moved in turn by a suitable combination of maneuvering and stabilization signals. Dynamically and equipmentwise, this is a very tempting system. However, problems arise in attempting to satisfy pilot demand for an absolutely fail-safe arrangement for emergency use.

One possible way of giving the pilot full mechanical emergency control would be to provide a clutching mechanism that would lock the pilot's stick to the control surfaces. However, an electrical failure could move the control surfaces to one extreme while the pilot moves his stick to the other extreme. To lock on at this point would make it impossible for the pilot to right the airplane since the stick is already at its extreme and can move no further.

An alternative might be to provide a centering mechanism to re-align the control stick and control surfaces before locking on to a mechanical mode. This would take considerable force, in fact, nearly equal to that of the pilot. This is possible and seems a workable solution until one considers what might happen if the human pilot should disengage the electrical system

(*Continued on page 45*)

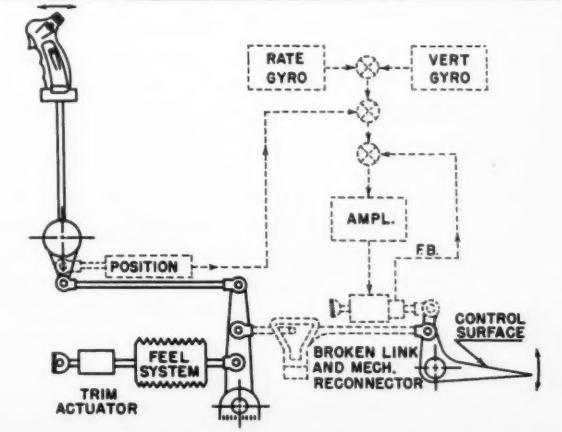


FIG. 12. Schematic—electric stick type of control stick steering.

Tooling Aspects of Heavy Skin Construction

C. S. GLASGOW*

Douglas Aircraft Company, Inc.

THIS PAPER will be confined specifically to the assembly tooling aspects of thick skin wing structures, particularly the assembly of large components such as spars, bulkheads, and skin panels in main assembly jigs. In order to solve the assembly problems of these structures, assembly tools have changed in character. The assembly tool for heavy skin wing construction has become an extremely accurate holding fixture that allows for the linear expansion of lengthy members and incorporates elaborate devices for the drilling of accurate holes, and, unlike its predecessors for the assembly of thin skin structures, it does not have to accommodate the additional manufacturing operations of trimming and shaping of parts on assembly.

Present-day designs of aircraft incorporating thick skins require higher performance of the airfoil shapes and greater efficiency from the structural joints. As a result, these designs present three problems to the assembly tool. These are:

(1) Tighter tolerances on the external airfoil shapes.

(2) Longer members requiring more allowance for thermal linear expansion of members.

(3) Tighter tolerances of the dimensions of holes placed in these structures for attachment purposes.

In order to illustrate the first problem, Fig. 1 has been prepared from the measurement of actual production wings over the past 20 years. This is a bar chart showing the amount of waviness of airfoil surfaces measured as depth of wave in 10 in. by the usual method of placing splines over the external surface of various wings. The wave as measured is chordwise. The various bars represent the measurement of actual airplanes, from the DC-3's in the early 1930's through the C-54's, DC-6's, C-124's, up through modern heavy plate structures of today. The last two bars on the right are waviness measurements from thick skin structures; the others represent thin skin construction. The solid black section of each bar represents the average depth of wave of all measurements taken on a given wing. The total bar represents the deepest wave measurement on a given wing. A definite trend may be seen showing the improvement in reduced amount of waviness of actual airfoils produced on these airplanes. It may be said that in 20 years—from 1934 through 1954—there has been a continual decrease from an average waviness of 0.040 in 10 in. to an average waviness of 0.010 in 10 in. It is interesting to note that there is a local flare-up or increase in waviness in the early World War II days. This can be attributed first to increased rates in production accompanied by an increase in factory personnel, which resulted in a decrease in average skill and a change in assembly tooling techniques in this period necessary to meet the increased rates. This resultant change in technique shifted the responsibility for producing a fair airfoil surface from the aircraft assembler to the assembly tool. This will be further explained in the paragraphs that follow. The improvement in reducing airfoil waviness as indicated by this chart has been made possible through a continual refinement of assembly techniques and assembly tools over the past 20 years.

In the 1930's metal aircraft wings were assembled by a so-called "internal tooling method." The assembly jig was a structural steel framework that located the internal parts, such as ribs and spars, on station and in

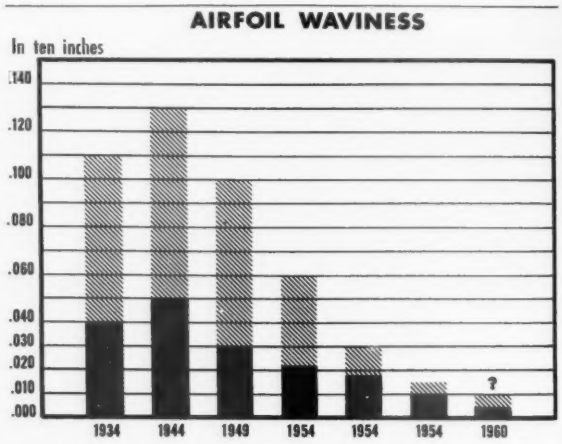


FIG. 1.

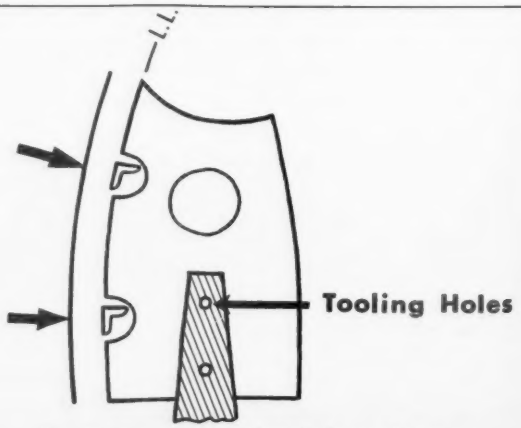


FIG. 2. Contour determined by internal structure.

Presented at the Aspects of Heavy Skin Construction Session, National Summer Meeting, IAS, Los Angeles, June 21–24, 1954.

* Chief Tool Engineer, Santa Monica Division.

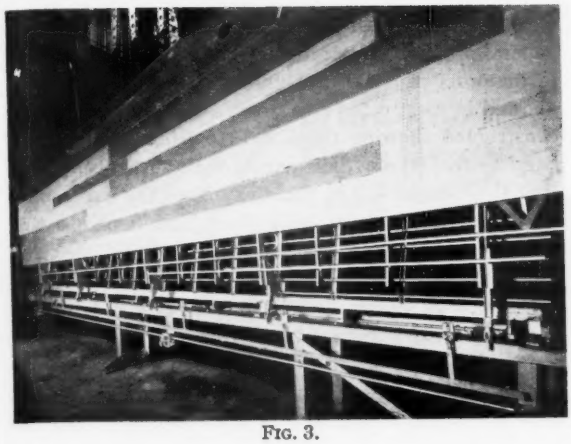


FIG. 3.

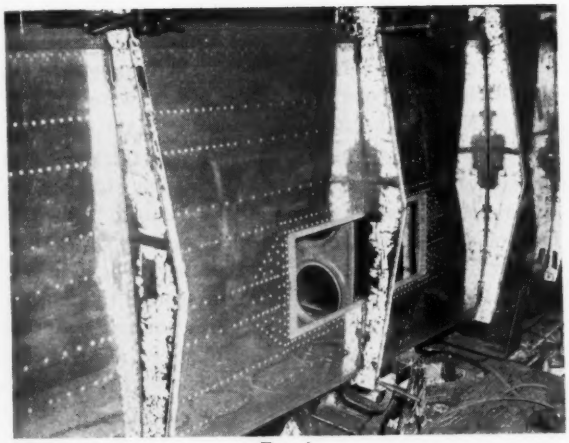


FIG. 4.

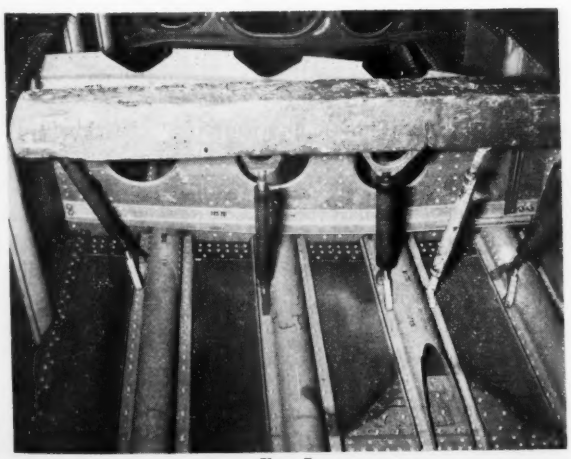


FIG. 5.

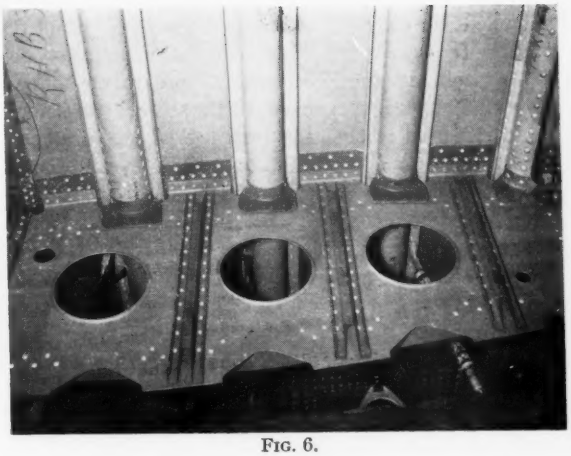


FIG. 6.

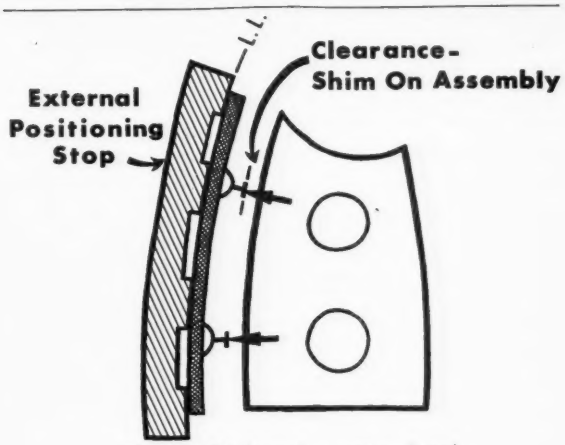


FIG. 7. Skin formed to contour board.

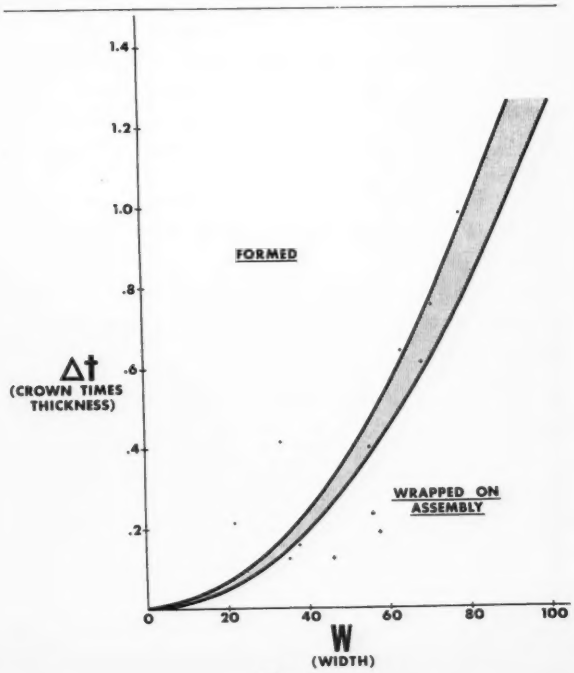


FIG. 8.

alignment by means of tooling holes in the body of the parts. To these parts, then, external structures such as longitudinals (small extrusions and rolled shapes) were applied. Being thin gages, the stiffening members could easily be twisted and bent to make a fair shape, during assembly, by the aircraft mechanic. Finally, flat sheet skins were applied and wrapped by hand, or with low clamping forces, about this internal framework. The skins were generally trimmed and drilled on assembly. The aircraft mechanic could slightly shift the several members about and in so doing and with his skill provide a nicely faired surface. The accuracy of the external shape of the assembly was dependent upon his skill and upon the dimensions of the internal parts. This system was typical of methods used on the DC-3. (See Figs. 2 and 3.)

In the early 1940's there was a shift to the so-called external type of tooling. This type of assembly tooling consisted of providing contour bars, located at various stations in the assembly jig, which contained the external shape of the airfoil desired. The internal structure of ribs, spars, and bulkheads was placed in position and held by the structural steel assembly jig. Skin panels with the longitudinal stiffeners attached were then placed in the jig and, before attachment to the ribs, were pressed out against the contour boards that bent them to the external shape of the airfoil. (See Figs. 4 and 5.) Then clips that attached the external skin panel to the internal ribs were drilled and riveted on assembly. (See Fig. 6.)

This method of pressing the external surface out to these carefully tooled contour bars provided a more consistently fair surface and, removing the chore from the aircraft assembly mechanic, placed most of the responsibility for this fairness in the assembly tool. (See Fig. 7.)

With thick skin wing construction, assembly tooling and assembly techniques have changed again. There are obviously thicker skins with crown so slight, or with width large enough, that they, too, could be shaped on assembly by wrapping in the assembly jig without experiencing excessive stress in the skin panels or without requiring excessive forces (clamping forces) to wrap or bend them to shape.

Fig. 8 is a curve showing possible limits for wrapping or forming a skin. This curve graphically illustrates the formula:

$$f = (4\Delta \cdot Et)/W^2$$

where

Δ = crown of the panel, in.
W = width, in.
t = thickness of the skin, in.
f = unit stress (in the extreme fiber) due to bending from end couples that deflect the sheet equivalent to the crown

This formula is derived from the deflection formula of a cantilever beam with end couples.

In discussion with the structures engineers it was the general opinion that transverse stresses in skin panels in the order of 5,000 to 6,000 lbs. per sq.in. would be allowed in most cases as a prestress. Thus Fig. 8 was constructed showing the 5,000- to 6,000-lb. per sq.in. band as the limit. Skin panels with such proportions that they would fall in the area above the curve must be shaped in the fabricating stage. Skin panels that could be wrapped to shape on assembly would fall below the curve.

Dimensions were gathered from heavy skin construction in existing production at three separate aircraft companies. The small dots shown in Fig. 8 indicate twelve of these actual production tapered-skin panels. It is not a desirable assembly technique, from the tooling and manufacturing standpoint, to force assemblies into position. Large forces of this nature require the assembly jig to be made of large members in order to maintain accuracy. Further assemblies made with large spring forces in the assembled units relieve themselves when removed from the jig and change shape, again reducing the accuracy of the assemblies. Thus, from the practical standpoint, there is a lower-limit curve that might be shown for wrapping of skins. Of all the skin panels shown only two were actually wrapped to contour in the assembly jig.

It may be concluded that most of the thick crowned skins must be shaped in the fabrication stage. Furthermore, these skin panels must be trimmed in the fabrication stage as they are too thick (as a whole) for economical trim-on-assembly operations. Therefore, in thick skin wing construction the assembly tool has reduced functions over its thin gage construction predecessors. It no longer has the functions of trimming and contouring the skin panels. This is a fundamental difference. As its primary function, it serves to hold accurately in alignment (relative to the reference planes of the wing) the various structural components, which come to it completely shaped and contoured; second, it serves to set the overall dimensions as to the depth of the airfoil; and, third, it provides the means of drilling very close tolerance holes on assembly of these parts. Although contour bars and so-called external tooling are still a necessity, these bars become more of a stop against which the completely shaped skin panels are pressed, and as such they do control the overall depth of the assembly, but the local waviness of the air foil is set in the detail fabrication of the skin itself. Because of collected tolerances, clearance must be left between the skin panels and the internal structure so that these panels may be pressed against the external contour bars and then attached to the internal structure without constraint. This requires the use of clips drilled on assembly, or, if tension bolts are used, the shims must be used between the stringer bottoms and rib flanges. (See Fig. 8a.) It might be said that the assembly tool for heavy skin construction is a combination of internal and external tooling inasmuch as the detail parts set the local airfoil shape and control the local waviness, but the overall dimensions of the wing

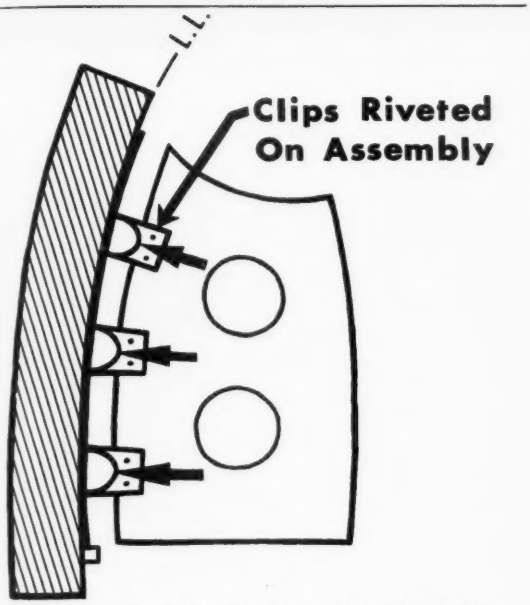


FIG. 8a. Contour determined by preformed thick skin.

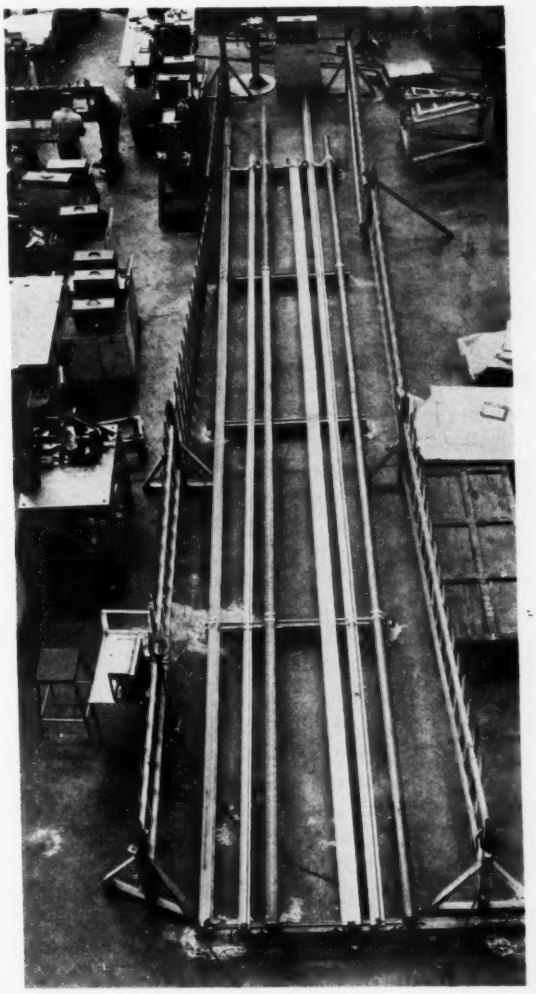


FIG. 9.

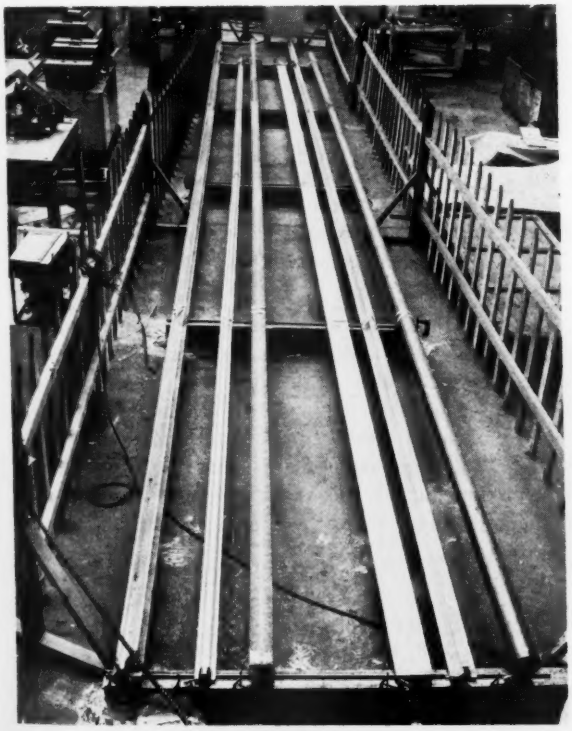


FIG. 11.

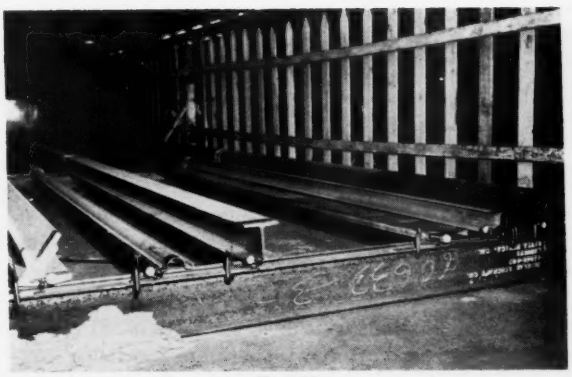


FIG. 10.

are set with external contour bars attached to the assembly jig.

Directing our attention back to Fig. 1, we may see that further improvement in airfoil waviness has been experienced with thick wing skin construction as described above. Fig. 1 shows a reduction in airfoil waviness down to 0.010 in 10 in. Through the past 20 years the responsibility for controlling airfoil waviness has shifted from the skill of the aircraft mechanic to the assembly tool and, with thick skin construction, to the fabrication tool.

And now to discuss the second problem: longer members in thick skin construction require more allowance for linear thermal expansion of members during assembly. Inasmuch as the gages are heavier, the cost in weight to the airplane for joints is greater. Furthermore, with tapered skins, the need for joints to step down gages is removed. Thus designs would obviously be toward a minimum of joints, with longer members the result. The assembly of longer members is a problem because of the linear expansion of these members with variations in temperature. This is a problem that was faced by tool designers in the past but to a smaller degree.

The problem first arises since the assembly jig is normally of steel, and the air-frame assembly is aluminum alloy, which has nearly twice the coefficient of linear expansion of the steel jig. A 50-ft. dimension in the steel jig will be 50 ft. and $^{5}/_{64}$ in. with an increase of temperature of 20°, or let us say from midnight until noon, whereas the aluminum-alloy assembly 50 ft. long would increase to 50 ft. and $^{5}/_{32}$ in. during the same period. To illustrate this point further an experiment was conducted to demonstrate the problem in variation in length of different types of materials and different cross sections of the same materials. Fig. 9 is a photograph showing six pieces of material which were observed. Fifty-foot pieces of 4-in. black iron jig pipe $^{1}/_{4}$ in. thick, structural steel 4-in. H-beam $^{1}/_{4}$ in. thick, aluminum-alloy extruded spar cap $1^{1}/_{2}$ in. thick, aluminum-alloy Y extrusion $^{1}/_{8}$ in. thick, aluminum-alloy rolled hat section 0.080 in. thick, and a magnesium extruded channel shape 0.081 in. thick were all secured to the floor at one end. Dial indicators were placed at the opposite end. Throughout the day and night the ambient air temperature, the surface temperature of the material, and the change in length of the several members were observed and recorded. (See Figs. 10 and 11.)

Fig. 12 is a chart of the results. It may be seen that within 6 hours after all were cut to exact length, there was a spread of some 0.040 in. in the length of these various members. In 12 hours, there was a spread of 0.200 in. The actual change in length of these members is not large. It is of the order of magnitude conceivably permissible in the design of such assemblies. The problem is complicated since these members do not expand and contract by the simple laws based on the ambient air temperatures. There are too many contingencies such as radiant heat from the factory roofs and drafts when the hangar doors are open. It is the rapid rate of change in length that is a problem to tooling and manufacturing personnel trying to make accurate assemblies of these long members that are cut or set to length at various times of the day and at various temperatures.

One solution would be to work in temperature-controlled atmospheres; this is obviously uneconomical. The second solution, which has been tried, would be to make the assembly jig and the air frame of the same material. This does not entirely remove the problem though, since varying cross-sectional shapes do not all expand consistently. Serious consideration is being given to all aluminum assembly tooling for certain future assemblies.

The third solution is being practiced at present and consists of designing the assembly jig with one end fixed as the inner end of a wing panel and allowing the other end of the jig, or so-called outer end gate, to float. This outer end gate is held in alignment by the steel structural framework of the jig but would be positioned as far as length is concerned by one of the lengthy members in the assembly, such as one of the spars. All other lengthy members would come to this assembly without the end fittings attached or with provision so that the end closing bulkhead could be trimmed or positioned relative to the one member only. This method is practiced on the DC-7 center wing. The center spar is used to determine the overall length of the assembly, which is about 70 ft. The end gates of the assembly jig are attached to this spar. When the front spar is loaded into the jig it is without its end fittings (Fig. 13). These end fitting are attached to the spar by using the end gate to determine the overall length. The end gate and center spar also position the closing bulkheads that determine the overall length of the assembly. (See Figs. 14 and 15.) By actual measurement of eight consecutive assemblies there was a variation in length of the front spar relative to the center spar of as much as 0.130. Allowance for this sort of linear expansion of long members is even more necessary in heavy skin structures since the tendency is toward longer members and fewer joints.

And now to discuss the third problem of assembly tooling of thick skin wing construction. The increased thickness of the attaching members dictates the use of close tolerance bolts. Holes for such close tolerance bolts must be held to diametral tolerances of 0.0016. The following is a table of the diametral tolerances in drilling holes on assembly in aluminum-alloy plate. It is obvious that for close tolerance holes in thick skins reaming or broaching of these holes is necessary.

	Diametral Tolerance
Drill, only	0.007
Drill, with bushings	0.004
Drill and core drill	0.002
Drill, core drill, ream	0.001
Drill and broach	0.0005

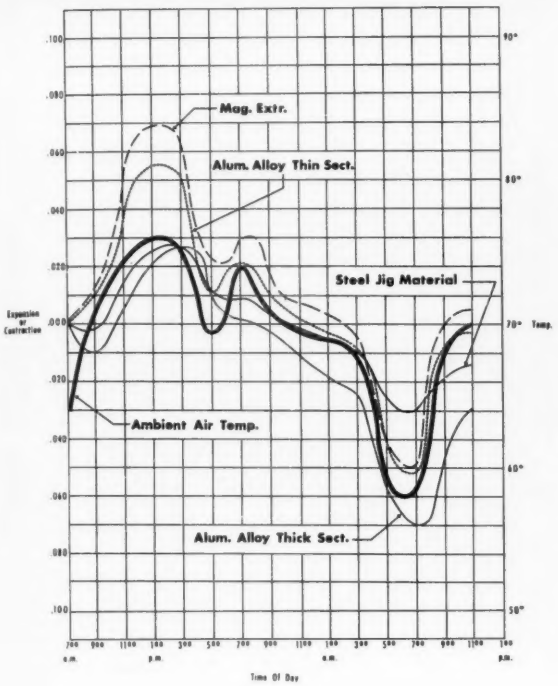


FIG. 12.

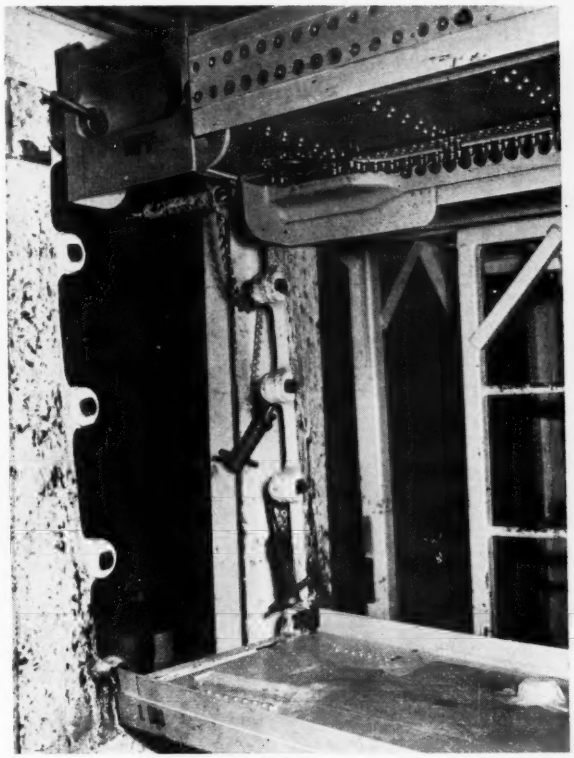


FIG. 13.

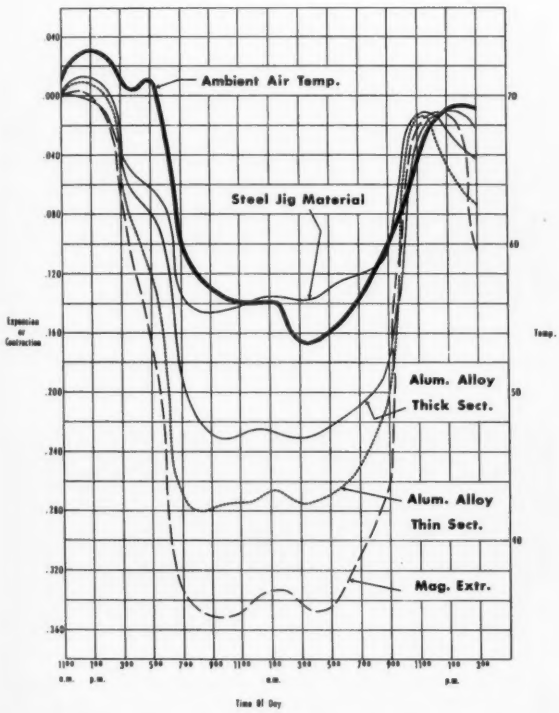


FIG. 12a.

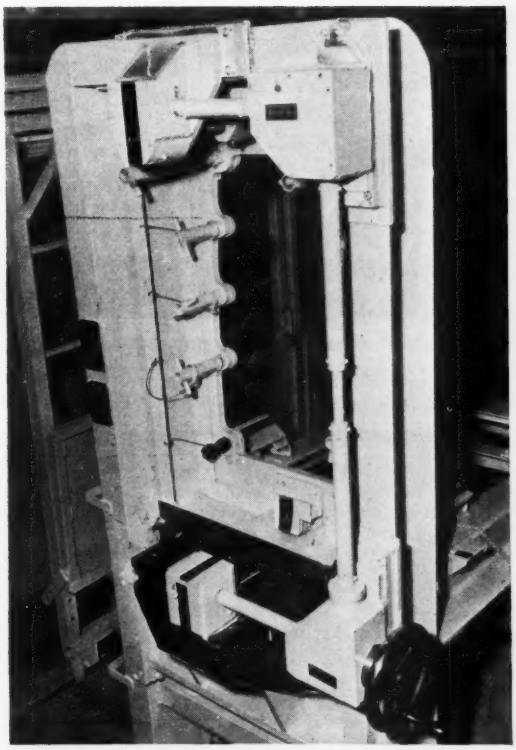


FIG. 14.

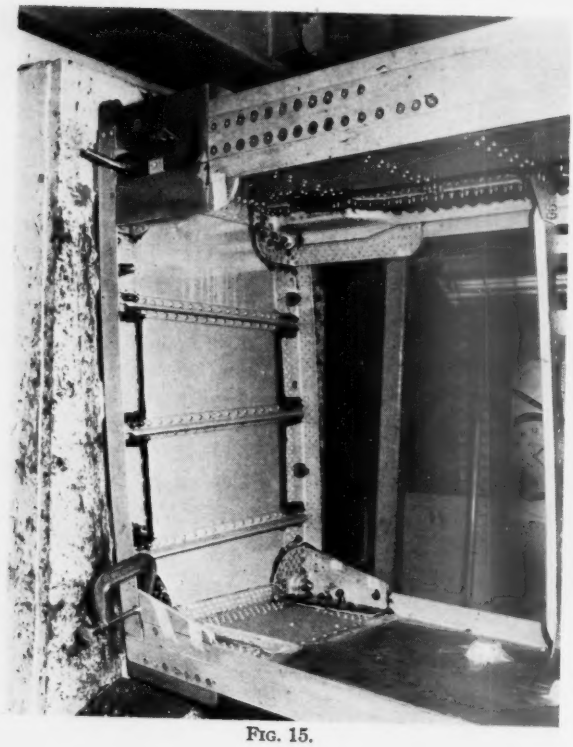


FIG. 15.

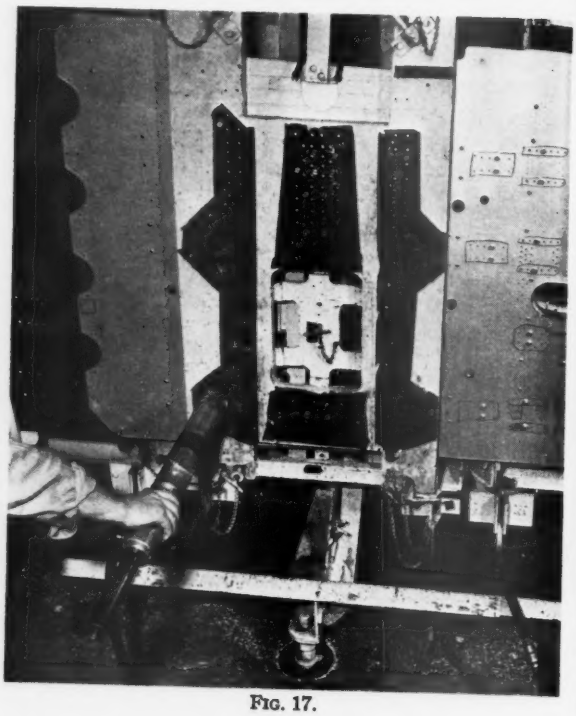


FIG. 17.

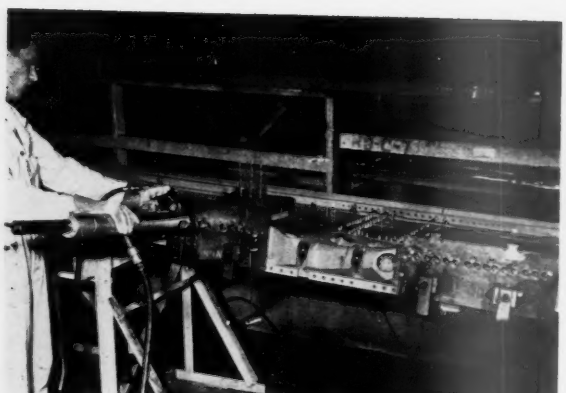


FIG. 16.

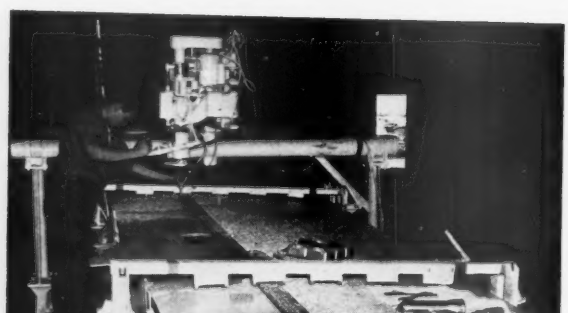


FIG. 18.

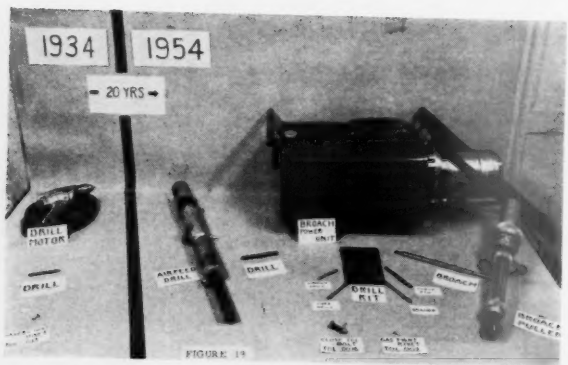


FIG. 19.

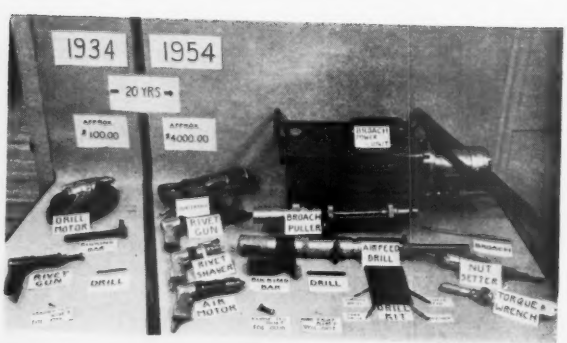


FIG. 20.

The making of many such holes has required that the assembly tool become an elaborate drill jig with thick steel drill bars containing accurate bushed holes. These drill bars are necessary, first, to get a straight bolt hole without taper or oval; second, to space the hole accurately; third, to align accurately the centerline of the hole normal to the surface of the skins. Finally, these drill bars must contain means for attachment of mechanical or air-fed drill motors so that the drill is uniformly fed into the material. This is necessary in thick materials to get an accurate hole and to relieve the fatigue to operators. (See Figs. 16, 17, and 18.)

To illustrate the increased complexity of the problem in making holes in heavy plate structures, the increased cost can be used. Figs. 19 and 20 illustrate this increase in cost. Looking to the future—if further tightening of tolerances is required, then these particularly elaborate drill jigs and costly hole-making devices will be replaced with even more elaborate devices, which will result in very precise machine tools such as accurate jig borers and horizontal boring mills.

In conclusion it may be said that assembly tools have changed in their design over the past 20 years in order to meet the requirements placed upon them by engineering design. It may be said that there has been a shift in the responsibility for accuracy. In the early days of metal aircraft, the prime responsibility for external fairness and lack of skin waviness was upon the aircraft assembly mechanic. This responsibility shifted somewhat with the increased rates of production to where it was placed mainly upon the assembly tool and now, with heavy skin construction, has again shifted to where the fabricating or detail tool that shapes the heavy plates before they reach the assembly tool has the major responsibility in producing extremely smooth surfaces. With heavy skin construction today, waviness in the order of 0.010 of 1 in. in 10 in. is to be expected. If engineering design requires less waviness than this in the future, the external surfaces will have to be shaved to shape as a machine operation *after* assembly. It may also be concluded that heavy skin construction, with its tendency toward longer members, has amplified the problem of the linear expansion. If further control and accuracy are required in lengthy assemblies, then here, again, machining by cutting to length after assembly with milling machine heads mounted on the assembly tool—particularly at its attaching joints—will be necessary. And, finally, heavy skin construction has greatly increased the cost and problem of making many close tolerances holes for attachment purposes in these assemblies. If further accuracy is required, it will be obtained only through extremely close boring of holes during assembly with machine tools somewhat the type of the jig mill or jig borer. It may be concluded, then, that to obtain closer tolerances of heavy skin construction, machining after assembly will be the solution.

Control Stick Steering for Stabilized Aircraft

(*Continued from page 37*)

without having a firm grip on the stick. Then much of the centering force would be reflected at the stick, which would slam home to its correct position with a force great enough to break an arm or a nose. Furthermore, mechanical recentering devices of high force output tend to become quite large and heavy.

Another problem with the electric stick is that in its simplest form it does not satisfy the pilot's requirement that stick position reflect surface position—that is, with the system operating normally, the surface position is commanded by a combination of stick and gyro signals. Thus, if the system is not working properly, the surface position could be anywhere with the stick centered. This is not an acceptable arrangement.

However, as supersonic aircraft become more prevalent, the added complexities of mechanical control systems will make a variation of the electric stick more tempting. It seems certain that it is just a matter of time until the production application of some version of the electric stick.

(VII) Conclusions

From the foregoing it can be seen that systems of control stick steering must be evaluated in terms of the requirements for a particular aircraft and its mission. One or more types may be used in the various axes of a single airplane. It must be kept in mind that the only justifications for control stick steering are the comfort, convenience, and safety of the human pilot. Selecting a system on the basis of preconceived notions or rigorous adherence to simplicity defeats the whole purpose of control stick steering. It seems certain that simplicity and naturalness of operation are bigger factors in pilot acceptance than hidden complexity.

The Orenda and the Future

Mechanical Design Considerations in Canada's First Production Turbojet

B. A. AVERY*

Orenda Engines Limited†

NO ONE COULD HOPE TO DISCUSS all of the mechanical design of a turbojet engine in a paper of this size. Instead I should like to outline briefly the role of the mechanical designer in the aircraft engine business; to use portions of the Orenda engine to indicate how the problems originally encountered were met, where the theories broke down and were corrected, and how some units would be designed at the present time; and, finally, to mention some of the design problems that will be encountered in the near future.

The design of the Orenda was commenced 8 years ago this month, and it is now in full-scale production as the Orenda 9 for the Avro CF100 all-weather fighter aircraft and as the Orenda 10 for the Canadair Sabre V. An uprated version incorporating a two-stage turbine is entering production in two similar versions as the Orenda 11 for the CF100 and the Orenda 14 for the Sabre, but the design cannot be the subject of discussion for security reasons.

The turbojet engine began its existence as quite a simple piece of equipment, but through the years it has evolved into a more and more complex machine. Part of this, I agree, is due to the fact that the functional requirements have become more and more stringent, power requirements for a given size and weight have increased, and the envelope of operational conditions has grown ever broader. But there is another reason for this increase in turbojet complexity, and it can be laid directly at the door of the mechanical designers.

Engine design is a program of studying performance and functional requirements, manufacturing techniques, material properties, and past experience; making layouts; and choosing the best of these for transposition to engineering working drawings. It also includes the careful study of proprietary items and usually close liaison with the designers of these components leading to the completion of control drawings and specifications and the final inclusion of the best units into the prototype engines. Now, if the designer does not have a complete knowledge of the manufacturing facilities, the properties of all the available materials, the past experiences of his own company and of others, and the performance and functional requirements, and if he draws only one or two layouts of a particular section of the engine and his superiors take just fleeting glances at the designs before approving one for detailing, then that design will have an excellent chance of being overly complex for the duties it must perform. However, if the designer has kept himself well informed of these important data; makes several sketches and layouts in striving for the utmost in simplicity, performance, and ability to function; discusses the design quite thoroughly with his superiors, the stress engineers, the materials engineers, and the planners and tool designers; then the chosen design will have a much better opportunity to be less complex and will quite possibly be functionally a much better design. It will be more easily manufactured and serviced and will have fewer parts, which usually means that it will be of lighter weight and should consume less of the operators' dollars during a longer, useful lifetime. If the designer is sufficiently aware of the results that will be experienced if his numerous estimations and assumptions are incorrect and if he realizes that engines are not frozen for production but are modified steadily for improved performance, his design configurations will be such as to allow these future changes to be made with a minimum of major modification.

Provided the basic concept of an engine is correct, only the few parts that do not function properly are modified during the development period, with the remainder going into service as originally designed. History has shown that engine designs do not become simpler or of lighter weight during the development period but tend toward increased complexity since, in this business, time is at a premium and the "fix it but don't change it" technique is all too often chosen. The actual prototype mechanical design period is comparatively short, and, of the total period of from 6 to 7 years in which a repetitive pattern is followed in the design, development, and production proving of a turbojet engine, approximately 15 months is available between the drawing of the first line on paper and the running of the first experimental engine. Now you can well understand that an engine is not completely designed within this short period of time. In reality, during the interim between the actual design periods the design staff, in addition to performing the duties of redesign as development experience dictates, is busy keeping up to date with materials progress, engine development, service experience, and manufacturing methods developments and modifying its design thinking accordingly. It is also gleaning what information it can concerning other power plants, since good designers do not hesitate to use the ideas of others if they are definitely advantageous. The design staff, in effect, is planning from day to day how to design the next engine or modify the existing ones when the opportunities

Presented at the CAI-IAS International Meeting, Montreal, Canada, October 14–15, 1954.

* Chief Design Engineer.

† Formerly A. V. Roe Canada Limited, Gas Turbine Division.

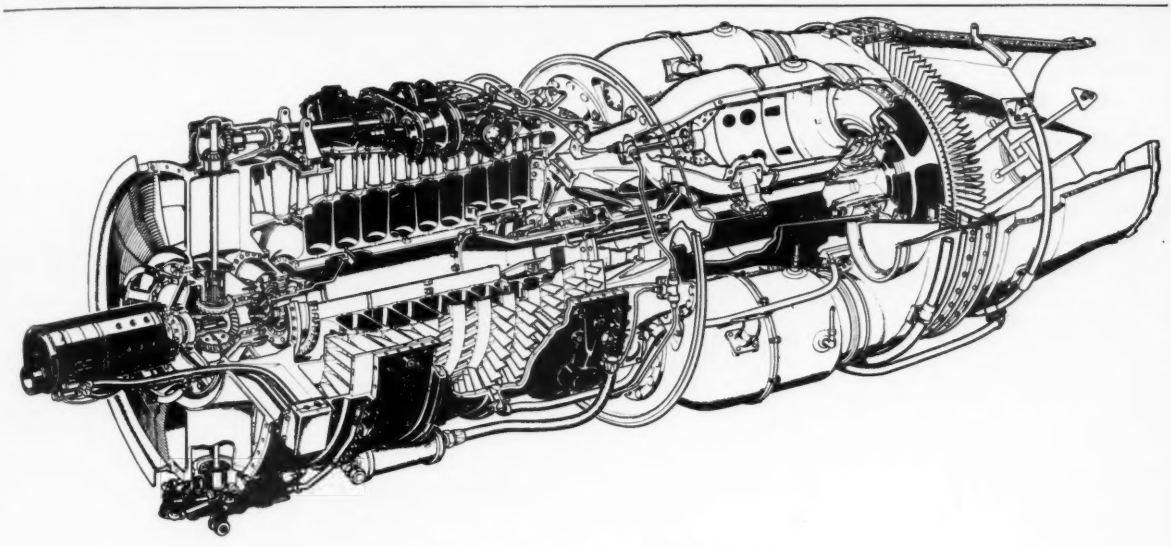


FIG. 1. A cutaway view of the Orenda 10.

present themselves. Intimate contact with the test and development engineers and the aero- and thermodynamicists enables an engineering department to provide good initial designs, make efficient use of engine development running time, correct aerodynamic and mechanical problems quickly, and provide proper technical service and control to the production program.

The usual result of all this is that long before an engine reaches production several design improvements have been evolved, and if these are of sufficient advantage they may be included as modifications. Once the production program is reached, however, the difficulty of their inclusion increases, but a situation sometimes arises in the production program where the procurement, manufacturing, and delivery status is such that a worthy modification may be included with a minimum of effort. More often, however, the inclusion of performance improvements in the production line provides the opportunity to incorporate mechanical improvements. Then if these have been proved sufficiently by development engine running and have been type tested and, of course, if the customer approves the changes may be incorporated. There are also many excellent design changes that cannot be fitted into the production program, even though they have been proved successful in experimental engines, and others that do not get to the experimental manufacture stage. These unused designs are filed for possible future reference.

The Orenda was designed quite conservatively for its time since the future of the Canadian-designed aircraft engine depended upon its running well the first time. It was designed to be equal to or better than the performance of the largest engines then on the drawing boards and to accept full fighter maneuver conditions up to speeds of Mach 1. Wherever possible, proved methods of construction were used since our own engine experience and research and development facilities were comparatively meager. Such features as an annular combustion chamber, which might have provided more opportunity for performance improvements but which would have required these facilities, had to be laid aside in favor of more conservative designs. Even with problems such as this, the Orenda combustion chambers are the largest and most efficient, and the compressor provides the highest pressure ratio and efficiency for the number of stages used of any similar engine of its generation.

Fig. 1 is a sectional drawing of the Orenda 10 engine. Basically it consists of a ten-stage axial flow compressor, six combustion chambers, a single-stage axial flow turbine, and an exhaust cone. The forward frame of the compressor supports the forward end of the compressor rotor, houses the power take-off gearbox for driving engine and aircraft accessories, and supports the compressor inlet vanes and, in the case of the Orenda 10, a starter-generator. The mid-frame, which is connected to the front frame by the compressor stator assembly, houses the main rotor thrust bearing, incorporates the main engine support trunnions, and acts as the compressor diffuser and transition from the annular compressor outlet to the six combustion chambers. The rear frame of the engine, which is connected to the mid-frame by a central backbone structure, supports the turbine rotor, acts as the transition from the six chambers to the annular turbine passage, and supports the turbine nozzles. The exhaust cone is connected to the rear frame and acts as the transition from the annular turbine outlet passage to the circular tailpipe section. The various engine accessories are mounted around the compressor casing.

The compressor stator casing, Fig. 2, consists of two magnesium castings bolted together at horizontal flanges. The original design shown at the top of Fig. 2 consisted of aluminum half rings, supporting the blades in broached slots and clamped against the inside of the

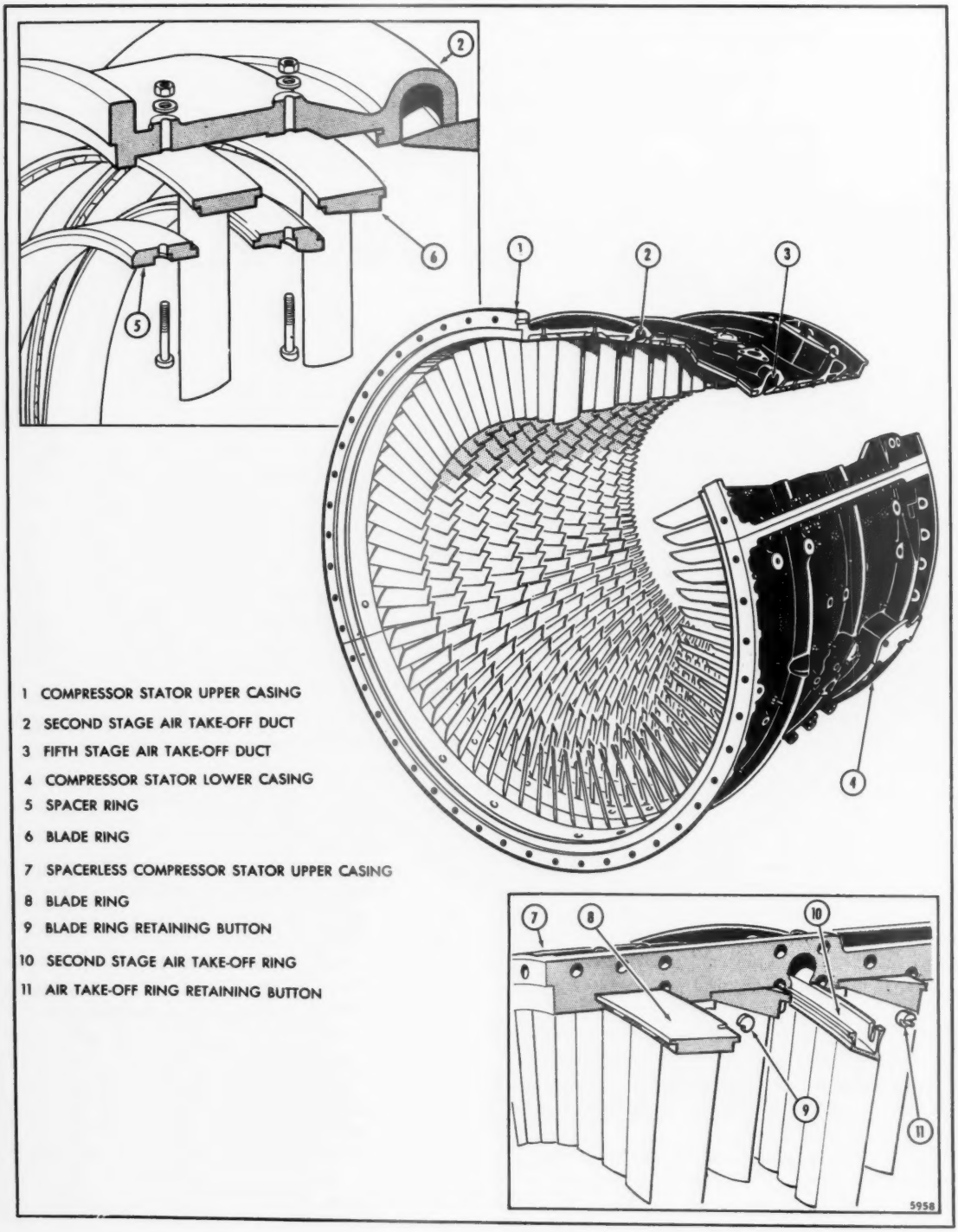

1 COMPRESSOR STATOR UPPER CASING
2 SECOND STAGE AIR TAKE-OFF DUCT
3 FIFTH STAGE AIR TAKE-OFF DUCT
4 COMPRESSOR STATOR LOWER CASING
5 SPACER RING
6 BLADE RING
7 SPACERLESS COMPRESSOR STATOR UPPER CASING
8 BLADE RING
9 BLADE RING RETAINING BUTTON
10 SECOND STAGE AIR TAKE-OFF RING
11 AIR TAKE-OFF RING RETAINING BUTTON
5958

FIG. 2. Compressor stator.

castings by intermediate aluminum rings and steel bolts. The reasons for this method of construction were the fear of fire as a result of rotor blade rubbing directly on the magnesium casings and the fact that it was a proved design. However, our own development experience and the service experience of other engines have proved the absence of the fire hazard and the suitability of another construction shown at the bottom of the figure. The same aluminum blade rings are now mounted directly in T-slots machined in the inner walls of the casings. Three similarly mounted rings form the air take-off manifolds. Simple aluminum buttons inserted at the horizontal flanges prevent the rings from rotating. The elimination of the spacer rings and bolts and the resultant decrease in tolerance build-up allow the inner gas profile to be machined at the same time as the slots are machined in the casings. Casting tolerances were such that in order to obtain wrench clearance at the casing flanges both spot facing and end milling operations were required, but, in this design, the outer diameters of the casings adjacent to the end flanges were decreased without decreasing the metal thicknesses so that simple automatic end milling operations now suffice. Machining and assembly times have been decreased considerably, structural strength and rigidity have been increased, and the weight is naturally somewhat less.

The compressor rotor shown on Fig. 3 consists of three aluminum drums, two steel shafts, and ten bladed discs shrunken onto the drums with spacer rings between their rims. The three-drum construction was used to enable the end discs to overhang the bearing shafts, thus decreasing bearing center distance and providing a more rigid rotor for a given weight. In actual fact this has proved itself to be one of the most stable compressor rotor designs of its generation. Originally it was felt that the disc hubs had to be accurately positioned axially to prevent dishing of the webs. Several shims were used to allow for tolerance build-up with the result that a substantial part of the assembly time was used in the determination of shim thicknesses. Engine running proved that as long as assembly web dishing was not severe, the hubs would find their own positions during operation. By the simple redimensioning of the drums, discs, and spacer rings, the shims and the calculation of, and the grinding to, the required thicknesses have been eliminated, decreasing assembly time considerably. The flanges of the drums and shafts began life as the reverse spot-faced buttress type to decrease the probability of stress concentrations. Laboratory testing proved that when properly designed, turned flanges would suffice, and the reverse spot-facing operations no longer are required. The bolt holes of the mating flanges were previously line reamed on assembly, and the bolts were selectively chosen for a snug fit. By close control of the hole sizes and positions and the bolt diameters, complete interchangeability has been achieved and the assembly reaming operations eliminated.

Each blade of the early engines was hand fitted in its support slot by removal of material from the bottom of the dovetail and the checking of the tip movement. Experimental testing proved that the fit tolerances could be increased sufficiently so that proper dimensional control of blade roots and disc slots would eliminate the hand fitting. Blades are now taken from stores and assembled directly and at random into the discs, with a considerable decrease in man-hours per assembly.

The center frame, Fig. 4, is an aluminum-alloy casting and has changed very little physically during its history. The backbone support bosses and gussets were enlarged to accept, without yielding, the extremely high maneuver bending forces and the axial gas load of the combustion chambers. Originally, the combustion chambers were each fastened to this frame by 14

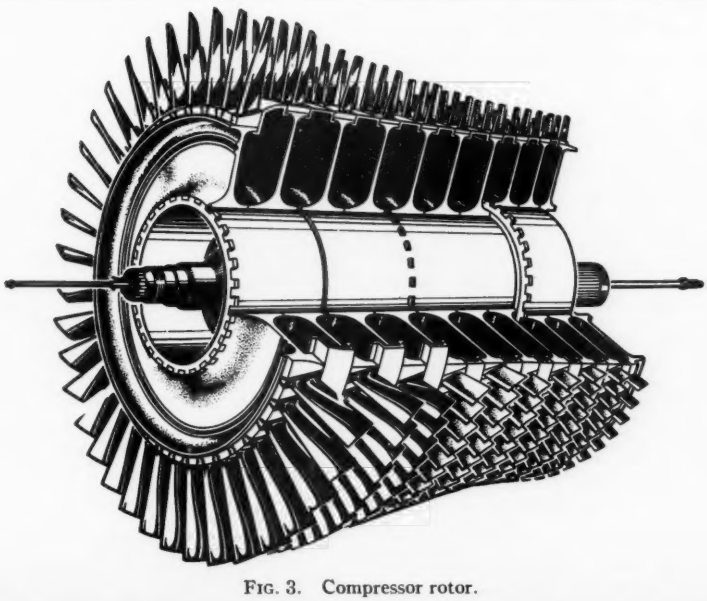


FIG. 3. Compressor rotor.

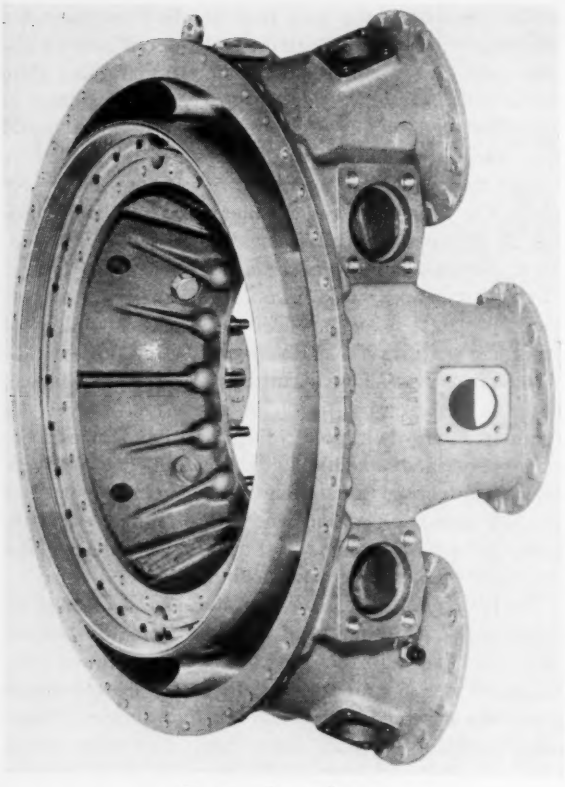


FIG. 4. Center frame.

bolts to provide sufficient flange pressure for sealing air using a standard gasket. The development of an elastomer able to withstand the temperature in the form of O-rings at this position has provided a sealing means using only two bolts per flange, with an increase in sealing efficiency and a considerable decrease in assembly and combustion-chamber liner inspection time. The successful development of a magnesium alloy of slightly better properties at operating temperature than aluminum alloys available has provided a slightly stronger structure and with a weight-saving of approximately 40 lb.

The labyrinth seal that can be seen fastened to the front face of the center frame minimizes the loss of compressor delivery air and lowers the pressure behind the compressor rotor in order to decrease main bearing thrust loads. The disc rim rotates inside of the seal within a radial clearance of about 0.015 in. In order to overcome the considerable thermal expansion differential, the seal assembly originally consisted of three main parts as shown on Fig. 5a. The steel mounting ring was slotted at the flange adjacent to the aluminum structure to allow for thermal expansion differential. Being extremely thin, it was difficult to machine and quite unstable. The ring riveted to it was also of steel, and the theory was that the average deflection of this ring and the aluminum gland ring fitted inside of it would be nearly the same as the sum of the thermal and centrifugal expansions of the disc. This proved to be correct, but the aluminum yielded in compression and became loose upon shut-down. Rubbing then occurred as a result of this yielding and the eccentricities allowed by the unstable support ring. This increased the clearance, causing air leakage control to be quite difficult. The redesigned seal assembly, shown on Fig. 5b, consists of a rigid, easily machined, aluminum-alloy mounting ring that expands directly with the aluminum or magnesium mid-frames. Fastened to it by radial pins is a mild steel gland ring that is free to expand only thermally and thus to a slightly lesser degree than the disc. Minimum clearance is therefore realized during engine running, where it is required, while providing reasonable build clearance with less chance of assembly damage. The assembly is quite rigid, it is more easily manufactured, concentricity can be maintained, and air leakage control is much more definite. This may sound like a great amount of effort to improve a seemingly unimportant part, but when one realizes that the prime purpose of a turbojet engine is to pump air, it becomes obvious that air leakage is an enormously important problem and well worth careful design. A 1 per cent loss of this compressor delivery air can mean as much as a 2 per cent decrease in overall engine efficiency. Axial thrust is the major factor affecting the life of the main rotor bearing. This force is the net sum of gas loads of very large proportions which are balanced against each other. Thus, the pressure behind the compressor rotor acting on the large area of the last disc, if not controlled closely, will cause considerably increased bearing thrust and decreased life. The bearing thrust load varies with operating conditions from approximately 500 lbs. to 12,000 lbs., and an increase in average seal clearance of 0.010 in. could increase the load by about 2,000 lb. thus severely decreasing bearing life. This small part, then, is of double importance, and the redesign has increased significantly engine efficiency and bearing life.

Each of the six combustion chambers, Fig. 6, originally consisted of a nickel-alloy inner liner or flame tube, a cast aluminum-alloy front casing, and an aluminized mild steel rear casing. The small machined ring at the

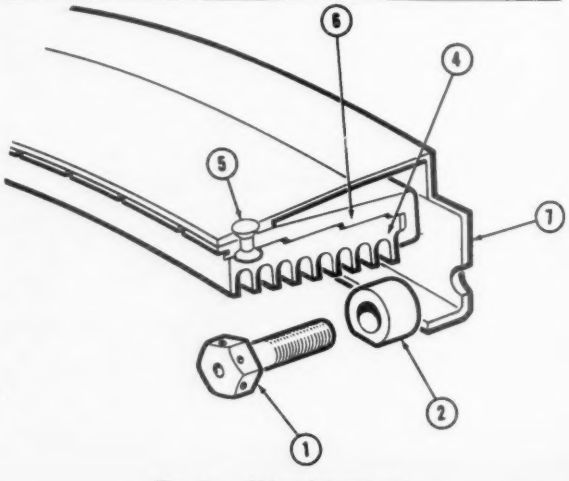


FIG. 5a. Old peripheral seal.

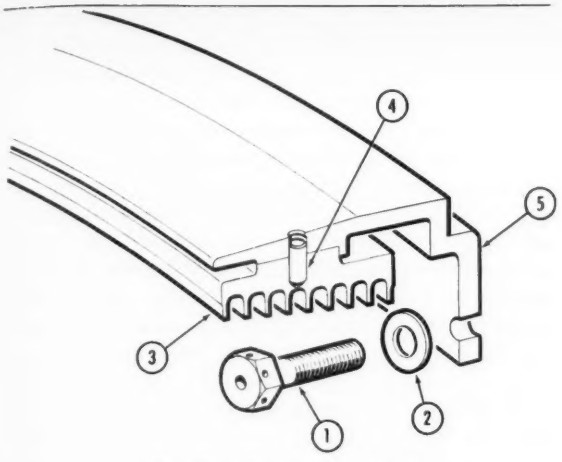


FIG. 5b. New peripheral seal.

front or snout of the liner was proved of no use and eliminated. The hand polishing operation for crack prevention on the edges of the various sections, including the holes, has been replaced by simple deburring with no increase in cracking. Since these liners are subjected to severe operating conditions, a considerable amount of development has taken place to increase the operational life, and this, combined with the manufacturing simplifications, provides a considerably less expensive unit per hour of life. The forward casing is now fabricated of mild steel to match the rear casing, since fabrication is quite in order for this structure. Fewer rejections are experienced, since welds can be reworked if not pressure tight, whereas the castings were rejected. The machined pilot diameters originally used at the center joint have been eliminated since the bolts connecting the two sections provide sufficient alignment accuracy. The sprayed aluminum coating on the mild steel rear casing has been replaced by a silicone paint protective finish, which provides more effective corrosion protection for both the front and rear casings, is applied more easily, and is less costly.

The nozzle box, Fig. 7, has undergone some change, but several tested design improvements have not yet been incorporated. The main bodies of the inner and outer casings were originally machined from rough stainless steel castings with a resultant long production flow time and a great waste of raw material in the form of swarf. Both of these structures are now fabricated of sheet metal, and rolled and butt-welded rings, resulting in a considerable decrease in weight, critical materials, and cost and an increase in rigidity by a simple redesign in the construction of the inner casing. If this structure were designed today, the outer casing would be enlarged at the forward end, the front diaphragm would be flat, and the combustion chamber support rings would be welded directly to it to eliminate the six adapter pieces and the forming operation for the conical diaphragm. The inner and outer casings would be integrated into a single welded structure for increased structural rigidity and decreased eccentricity, both of which affect turbine blade-tip clearances, and hence turbine efficiency. In this case, maximum sea-level static thrust can decrease as much as 15 lbs. for each 0.001-in. increase in average turbine blade-tip clearance. The scalloped bolting flanges at the front of the transition liners and the mating flanges in the main structure would be eliminated with the liners being piloted within the same simply bored rings used to support the combustion chambers. Positioning would be provided at the rear of the liners by unmachined sheet-metal supports. The manifold that surrounds the outer casing and carries waste bearing cooling air to atmosphere could be fabricated as an integral part of the inner casing, thus providing a decrease in weight and complexity.

The turbine nozzles are precision castings of a nickel-cobalt alloy and are individually mounted in supporting slots. This alloy can be machined only by grinding, and a considerable amount of it is required to finish the integral shrouds within the tolerances necessary. The development of a high-temperature brazing compound known as "nicrobraz" provides the designer with a much better solution in the design of turbine nozzles and other "hot end" assemblies. Fig. 8 is a sketch of a suggested method of utilizing this brazing procedure. The nozzles are simple castings with little or no machining and are brazed into sheet-metal shrouds in groups of five or six. The quantity of strategic material is less since the mounting shrouds can be of lower quality stainless steel; less machining is required on the mounting structures since the blades are mounted in groups rather than individually. The sheet-metal shrouds can be overlapped at their ends to decrease the amount of gas leakage around the ends of the nozzles. Although this type of construction can be performed by welding, the brazing operation causes such little distortion that usually no postbrazing machining operations are required.

The present exhaust cone, Fig. 9a, consists of a fabricated stainless steel outer casing and inner cone or bullet. Both are stiffened with spot-welded Z-stiffeners, and the bullet is supported by two sets of four crosstubes. The forward set of crosstubes is connected by external pipes and carries cooling air to the center of

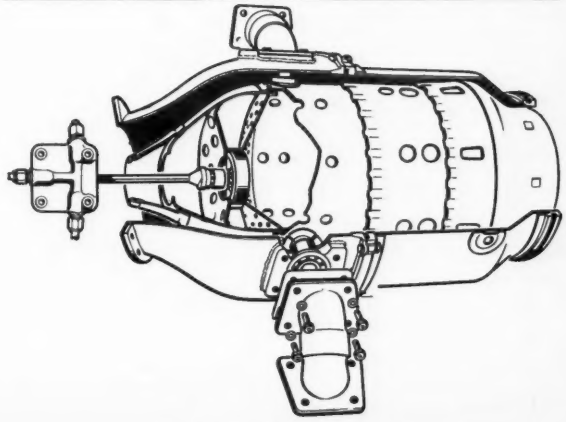


FIG. 6. Combustion chamber.

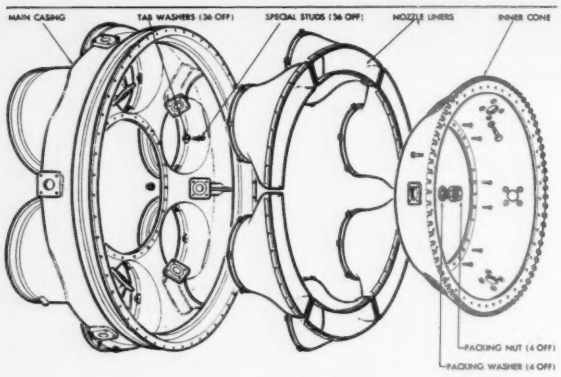


FIG. 7. Nozzle box.

the rear face of the turbine disc. Mounted on the support tubes are four streamlined vanes fabricated of folded skins spot-welded to internal formers or ribs. This construction, which was used almost universally 8 years ago and is appearing even on new engines, is complex and expensive. Cracking and buckling of the sheet-metal parts occur, especially in the vicinity of the stiffener spot welds because of thermal shock and vibrational fatigue. Various schemes have been used by the engine companies to increase life. However, most such solutions consist of the addition of extra stiffeners, doubler plates, and the like to overcome the results rather than the causes. Careful study of failures suggested that allowing the material to breathe with temperature variations and eliminating the spot welds and

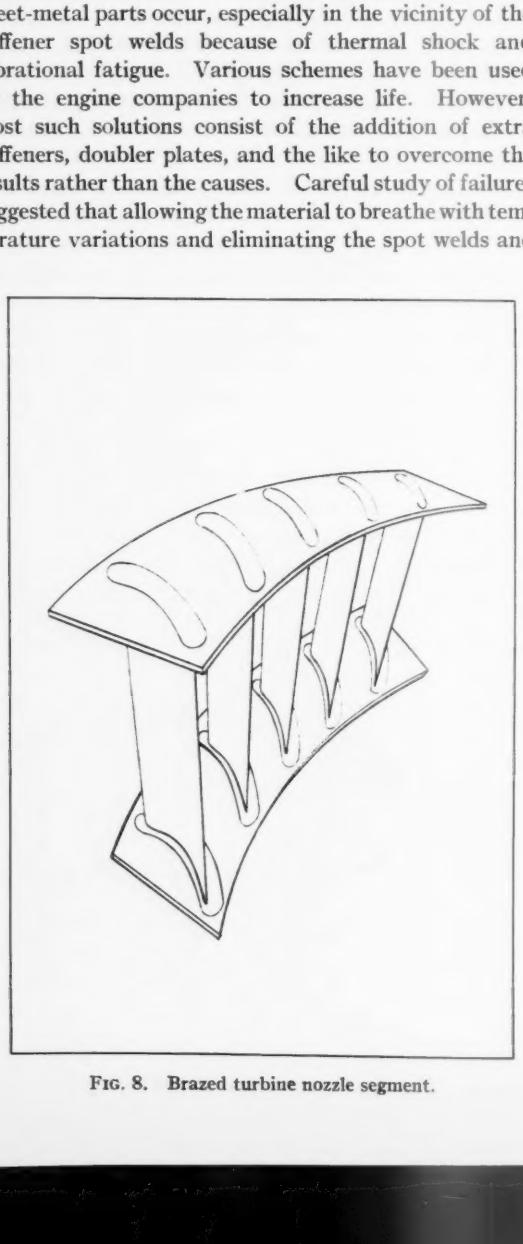


FIG. 8. Brazed turbine nozzle segment.

locally stiffened areas could greatly increase the life. When two sheets of metal are spot-welded together they are decreased considerably in thickness at the periphery of the nugget by the welding electrodes. The stresses caused in this area by the differential expansion of the hot skin and the cooler stiffener, combined with vibratory stresses, finally cause a crack that then progresses until severe failure occurs. The solution is the design shown on Fig. 9b which is much simpler and lighter and has a test bed running life such that the design is being readied for production of new engines and overhaul replacements. The outer casing Z-stiffeners have been removed. Four sheet-metal pressings, each consisting of one half of two vanes with integral pressed-in stiffening beads or corrugations and one quarter of the bullet, are fusion-welded together to form the complete unit. Internal stiffening plates in the vane root fillet areas were the only additions made during development and were necessary to overcome metal fatigue caused by torsional vibration of the bullet. An end plate on each vane incorporates a support sleeve that engages a hollow radial pin connected to the outer casing via a doubler plate. The bullet is thereby supported rigidly yet is free to expand radially. One of the support pins is connected to the center of the bullet diaphragm by a tube for carrying turbine cooling air, thus eliminating the external air manifold. This exhaust cone design is the result of a thorough study of the failure problems and correct diagnosis of the causes; it could not have been evolved without the experience gained on the original unit and is, I feel, a good example of design simplicity.

This philosophy of design simplicity must be used for future turbojet generations to an even greater degree since performance demands are increasing at an alarming rate. It took 50 years for aircraft to reach Mach 1, and, immediately, the topic changes to Mach 2. This trend to higher altitudes and speeds into the supersonic regions at altitude places the requirement upon the engine companies for military power plants of higher thrusts, with minimum increase in frontal area or weight and able to function over an ever-increasing range of operational conditions—from take-off to transonic speeds at ground level and to very high altitudes and supersonic speeds—all under temperature conditions varying from tropic summers to arctic winters. The increase in air-swallowing capacity required to provide high thrust, yet with minimum weight and frontal area, will necessitate the use of a very low hub tip ratio at the inlet of the engine. This will lead to long front compressor blading and a new realm in the vibration problem. Vibrational fatigue of blades in turbojet engines is a most exasperating phenomenon since the causes can be many, and, until the engine runs, the troublesome causes are unknown. Test bed engine running does not tell the whole story, but actual flight experience usually is required to develop a configuration free from blade fatigue. A glass-reinforced plastic construction for compressor blading is now in the development stages and has actually been operating in

test compressors with excellent results. This material is of about the same density as magnesium and at temperatures up to 250°C. provides comparatively high tensile strengths. Extremely light rotors will therefore be the result, but the main benefit will be gained from the fact that the high internal damping quality of the material provides excellent resistance against vibrational fatigue. Laboratory test machines have proved it almost incapable of this type of failure. Although the material is now capable of withstanding temperatures up to about 250°C., it is reasonable to assume that in the near future 375°C. operation will be a reality. This material will suffice for the first few stages of compressor blading and perhaps even for the discs and compressor casings, which can be molded to sufficient accuracy that only slight finishing should be required.

As aircraft speeds increase into the supersonic region, so the ram temperature rise increases, and at Mach 2.0 at 30,000 ft. on a normal day, for instance, the temperature of the air entering the engine is approximately 180°C., a normal oven-baking temperature; and this is the coolest natural air available in the aircraft. This increase in temperature will move the magnesium and aluminum alloys further toward the inlet of the engine, and in their place in the rear zones of the compressor titanium may be used. Titanium today is available in the engineering forms of sheet, bar, and forgings; as yet it can be cast only in a vacuum and is still an expensive material, running from $15 to $20 per lb. in these forms. The early machining difficulties experienced with titanium have been overcome considerably so that today it can be machined as readily as normal stainless steels. The higher strength alloys that can be used for compressor blading and discs are not weldable, but the lower strength, commercially pure titanium and a few alloys can be welded in an inert atmosphere. Fabrication of the material into structures such as compressor casings and major engine frames is therefore a fairly expensive operation. You can imagine the difficulties in the welding of a large structure inside a sealed chamber filled with helium. Even in spite of its great cost and difficulty of handling, titanium will definitely be a major structural material in aircraft engines, and in the very near future, since it has by far the highest strength to weight ratio of any engineering material and is corrosion resistant up to about 450°C. New methods of refining titanium which will tend to decrease the cost are now in pilot-plant production, and as the requirement for the material increases and the quantity of production thus increases, and it will, so the price will decrease still further.

The high strength at medium temperature aluminum and magnesium alloys are not weldable materials and therefore exist in engines mainly as castings. As these materials move toward the front of the engine and steel or titanium structures take their place, the structures will be welded or brazed fabrications of sheet, bar, forgings, and small castings. Since these materials have higher specific weights than aluminum

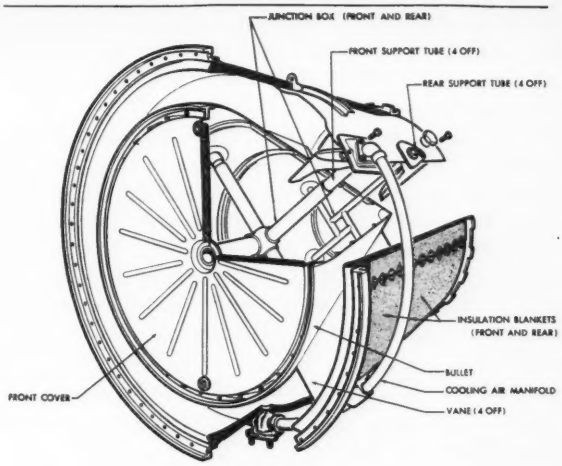


FIG. 9a. Old exhaust cone.

or magnesium and the modulus of elasticity to weight ratios are nearly the same, thinner sections can be used for the same rigidity. These thicknesses can be obtained more readily by rolling than by casting. The sheet-metal engine, as it may be called, is definitely the engine of the future.

One of the main methods of obtaining more thrust for a given size and weight of power plant is to increase the combustion temperature. This will increase the temperatures of the parts operating in or near the gas passage, such as discs, blades, nozzles, shrouds, and, of course, their supporting structures. New alloys providing better properties at temperatures or higher temperatures for given properties than of those in present general use are becoming available, and others are in the development stages. But even these will not carry us into the realm of combustion temperatures required for the future turbojet, and the air- or liquid-cooled turbine blade and nozzle will be seen in engines in the not-too-distant future. Cooling methods for blades

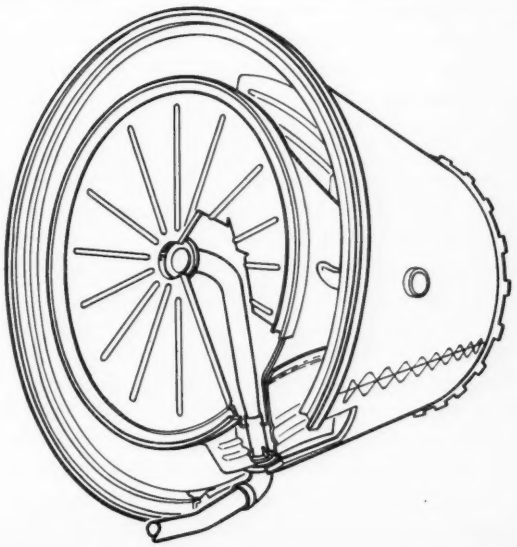


FIG. 9b. New exhaust cone.

have been developed and tested by several of our government research organizations; the problem now is to evolve configurations that can be produced in quantity.

Several companies have developed cemented carbide materials for nozzles and turbine blades. These cermets provide high strengths at high temperatures but, being extremely brittle, require special means of fastening to the discs or shrouds and are quite susceptible to vibrational fatigue. When these problems have been overcome the cermets may well add their part to the construction of future engines.

In most present-day turbojets, air is the primary bearing cooling agent, but at supersonic speeds, as mentioned before, the air becomes too hot, and the oil or lubricant will have to perform the cooling. This, again, will require cooling, probably, as at present, by the fuel in an intercooler. Under some flight conditions, however, there is the possibility that even the fuel will not be a sufficiently large sink for the heat rejection required, and artificial means will have to be used to keep the lubricant within its working temperature limits. Bearing steels have been developed which will stay hard at temperatures up to about 550°C., but we still do not have lubricants that will stand these temperatures. The oil and chemical companies have developed synthetic lubricants capable of operation at nearly 200°C., but lubricants that will operate at 350°C. and higher will be an absolute necessity. The requirement is for lubricants that will not break down in contact with the oxygen in the air at these high temperatures, and even the synthetic lubricants now in use in some of the newer engines have a tendency toward sludging or break down into a black sticky substance that clogs the screens and filters and even blocks off the passages between the rollers or balls and the races and cages. Lubrication will be a serious problem and could be the limiting factor since it seems that the development of lubricants has fallen behind the development of the other materials.

The elastomer compounds for O-rings and gaskets—the other main nonmetallic substances in the gas-turbine engine—are quickly reaching their thermal limits. The present materials such as the silicone rubbers and fluorinated polyethylenes are useful up to about 300°C. but materials for 500°C. operation will be a definite requirement since the construction of gas- and liquid-tight joints at high temperature is extremely difficult to effect without them. Considerable effort is being expended in an attempt to develop suitable metallic seals, but, to my knowledge, the flexibility of the elastomers has not been attained.

In order to handle the very high mass flows of the future engines, the "can" type of combustion chamber will probably be replaced by the annular type since a larger gas passage is obtainable within a given engine diameter. Considerable combustion development will be required to attain units capable of operating efficiently at temperatures and average gas velocities well above the 1,100°K. and 80 to 90 ft. per sec. now in general use.

Until such time as the combustion of the fuel toward the stoichiometric limit is possible in front of the turbine an afterburner may be used to increase the thrust of the engine during certain combat maneuvers, acceleration, and climb. Means of keeping this unit light, simple to manufacture and service, yet able to burn fuel efficiently at temperatures of 2,000°K. or more for a reasonable lifetime will be no easy task. It should have a fully modulated, adjustable final nozzle for optimum performance, and the control and fuel systems could be integrated with those of the main engine to form a single power-plant control.

These larger power plants, swallowing large quantities of air, will require very high fuel flows, and the normal gear or piston types of engine-driven fuel pump would be of tremendous proportions to handle these flows. These types could be designed to operate at higher speeds, or the air-driven centrifugal pump developed for afterburners might be used. This problem might be made clearer if it is stated that pumping capacities of 30,000 to 60,000 lbs. of fuel per hour will be required and upon further deduction it will be understood why the search continues for fuels possessing greater heating values than the 18,000 B.t.u. per lb. of the normal hydrocarbons.

The matching of the operational characteristics of a power plant to the operational characteristics of an aircraft will require that each engine installation be specially tailored to each individual aircraft. The days of the universal power plant are almost behind us, and much more effort will be required in the installation of the power plant in the aircraft than has ever been performed to date. The matching of the engine inlet and exhaust portions to the aircraft and the cooling of the nacelle will all require special attention for optimum performance over the ever-increasing range of operating conditions.

The control system of the future aircraft power plant will become more and more complex in its operational requirements. The wide range of operational aircraft conditions has been mentioned previously, and this control system will have to control the engine fuel flow for the various altitudes and temperatures; it will have to guard against rotor overspeed, overpressurization of the combustion chamber, and overheating of the turbine, and it will have to control the fuel flow to the afterburner. It probably will be integrated with parts of the aircraft control system to control such variables as Mach Number since the pilot will be too busy flying and navigating to have time for such items. In the design of such engine accessories, therefore, it becomes increasingly important that the philosophy of design simplicity be applied to the utmost in the execution of each mechanical function to avoid hopeless confusion in the overall result. When you visualize the maze of equipment practically covering the outside of the average turbojet—including the Orenda—you can well understand that, if simplicity is not the preliminary design keynote, this hopeless confusion could well develop as extra equipment is

added, and it usually is, during the lifetime of the power plant. These accessory details such as valves, pipe fittings, filters, solenoids, control levers, and others are the very items that keep aircraft grounded, mainly because they seem relatively unimportant and generally do not receive the same careful study as the major units such as discs and shafts. These tremendous trifles, as they may be named, must assume the same importance as the so-called major parts since grounded aircraft are poor weapons of defense or profit-making vehicles.

You have realized, no doubt, that materials will play an extremely important part in the design of future engines, even more than they did in the past. There are ever-increasing numbers each with its own particular properties, and the designer must familiarize himself with them as they are developed, since materials well utilized in a sound mechanical configuration can make a good aerodynamic design a useful power plant.

The importance of the power plant will increase with aircraft speed since it will become the most profitable place in which to expend our efforts in the search for optimum aircraft performance. Mr. Abe Silverstein, Associate Director, Lewis Flight Propulsion Laboratory, NACA, showed recently before the IAS that the engine and fuel weight increases from 25 per cent of the gross weight of a hypothetical aircraft designed to fly at Mach 0.5, to 40 per cent at Mach 1, and over 60 per cent at Mach 1.5. This is by no means the full story, but it indicates a definite trend.

Sherman M. Fairchild Publication Fund Papers

No.		Member Price	Non-member Price
FF-12	Transonic Testing Techniques (A Symposium)	$1.85	$2.50
FF-11	Wetted Area and Center of Pressure of Planing Surfaces at Very Low Speed Coefficients — Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-10	Improved Solutions of the Falkner and Skan Boundary-Layer Equation—A. M. O. Smith.	$0.75	$1.25
FF-9	A Hydrodynamic Study of the Chines-Dry Planing Body—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-8	Compressive Buckling of Plates Due to Forced Crippling of Stiffeners, **Parts I and II**—P. P. Bijlaard and G. S. Johnston.	$1.30	$2.00
FF-7	Natural Flight and Related Aeronautics—James L. G. Fitz Patrick.	$2.65	$3.50
FF-6	Wetted Length and Center of Pressure of Vee-Step Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-5	Symposium on Standardization in Technical Information Services for Government Contractors.	$1.00	$1.00
FF-4	Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders—F. K. Teichmann and Chi-Teh Wang.	$0.50	$0.85
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-2	A Study of the Flow, Pressures, and Loads Pertaining to Prismatic Vee-Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
AHS-1	Helicopter Flight Research at NACA, Langley—Jack P. Reeder.	$0.35	$0.75
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	$0.75	$1.25
244	Wetted Area and Center of Pressure of Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 30° Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium).	$1.85	$2.50
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley.	$1.15	$1.50
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman.	$0.75	$1.00
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	$0.35	$0.50
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	$1.85	$2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	$0.60	$0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	$2.65	$3.50
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen.	$0.75	$1.00

Papers should be ordered by number from:

Publications Department, Institute of the Aeronautical Sciences, Inc.

2 East 64th Street, New York 21, N.Y.

Flying Techniques with the Research Airplanes

A. SCOTT CROSSFIELD*
National Advisory Committee for Aeronautics

THIS THING OF FLYING TECHNIQUES with the research airplanes implies the methodology used in obtaining research results. The primary techniques are those methods that find and present the problems in their clearest sense.

Flight research differs from flight test in the emphasis upon searching out and assessment of problem areas and the specific problems. When the problem areas are found and assessed, all the complementary aeronautical research tools applicable are employed to attempt solutions to the problems. The completion of the cycle is proof testing the solutions in flight. It was the necessity of assessing the problem areas which forced the research airplane program into being as the logical extension of flight testing of some 40 years into a more scientific technique. Greater latitude for imagination in design and operation of test vehicles than was allowed by practical mission airplanes became imperative in the face of the rapid advancement of World War II.

The research airplane program that has been under way since 1944 was initiated to provide research information concerning flight in the transonic and supersonic speed ranges. It was necessary to go to these specialized airplanes because other research facilities at the time could not provide information in these ranges, and operational airplanes could only approach the transonic range in steep dives. The idea of these specialized airplanes was originally conceived by John Stack of the Langley Laboratory of the NACA. The original concept of the research airplane was simply that with existing knowledge, if the airplane were built strong enough to withstand any possible loading at the test altitudes and as small as possible—by eliminating all operational or military pay load except instrumentation—so that drag would be comparable to existing engine thrust permitting transonic speeds in level flight, then the machine would be suitable for transonic flight research. In order to put the idea into practice, considerable cooperation was required among the Air Force and the Navy (the procurement organizations), several of the aircraft companies and engine designers (the construction organizations), and the NACA laboratories (the research organization). The NACA's role has been at least twofold. One responsibility has been to provide research information so that the research airplane represented the latest thinking for the particular configuration. The second phase consisted of tests of the particular airplane, starting with wind-tunnel models and whatever facilities were appropriate and continuing on through with the research flight test of the completed airplane.

Ten years have now passed since the original proposal was made and 8 years since the first airplane of the series was flown. As would be expected, there have been changes in outlook and emphasis on the research airplane program as time progressed, and certain barriers have been overcome. The series to date has been comprised of eight different types of specially constructed airplanes and one type that was constructed as a possible production prototype. From this effort over 300 reports have been written covering theoretical studies and wind-tunnel and flight-test results dealing directly with the projects or problems generated by the results from these projects. As you can readily understand, it would be impossible at this time to cover all phases of these projects.

Although you are all probably aware to some extent of the characteristics of the airplanes in the research airplane series, it might be well first to look them over for refamiliarization. The majority of the airplanes are shown in the headpiece above. In the lower left-hand corner is the X-1A, which is a rocket-propelled

Presented at the CAI-IAS International Meeting, Montreal, Canada, October 14–15, 1954.

* Aeronautical Research Pilot.

airplane. This is a modification of the X-1, and, with the exception of a longer fuselage that permits greater fuel capacity and the more normal cockpit canopy, it is otherwise representative of the X-1 airplane that is not included in the photograph. This is the X-1A that recently set the record speed, approaching a Mach Number of 2.5 and a reported altitude of 90,000 ft. Immediately behind it is a D-558-I, which is powered by a turbojet engine. The X-1 and the D-558-I are the two straight-wing conventional section airplanes of the series. As would be expected, they were the first designed, and they are more nearly representative of the airplanes of the time than any of the remainder of the series. Behind the D-558-I is the delta-wing XF-92A, which has a turbojet and afterburners. To the right of the XF-92A is the X-5, also a jet-propelled airplane, which is unique in having a capability of varying its sweep in flight. Immediately in front of it is the swept-wing D-558-II, of which we have a turbojet and a rocket-propelled version and an all-rocket version. This airplane was the first to reach a Mach Number of 2.0. At the right front is the tailless swept-wing X-4, which is jet propelled. In the center of the picture is the X-3 airplane with a low aspect-ratio straight wing. It is powered by turbojets with afterburners. The large airplane length to span ratio is probably the direction in appearance of future supersonic airplanes whether they incorporate straight, swept, or delta wings. Both the X-1 and the D-558-II series are air launched from a B-29 mother airplane. The other machines take off under their own power. Missing from the photograph is the X-2 rocket-propelled airplane and the series of the low-speed L-39 airplanes, which are modified P-63's that we used early in the program to obtain some practical flying experience with swept-wing airplanes in the landing condition.

It might be well to discuss one of the basic aims of the program which is the exploration and exploitation of the maximum performance capabilities of these airplanes. This phase of the program has led to one of the most important results: this is the intangible confidence given by knowledge of repeated flight in a new speed regime. The first step in this direction was Major Yeager's first supersonic flight on October 14, 1947, showing that such flight was feasible. The current status of high-speed exploration is shown in Fig. 1, which shows the altitude and speed range explored with the research airplanes and the probable speed and altitude ranges of our current operational fighters. The X-1A altitude has been recently extended to a reported 90,000 ft. The limits shown are not static. The production airplanes are performance limited, whereas the research airplanes are limited by stability and control problems. It is our mission, therefore, to learn the answers to these problems at a faster rate than the performance is increased in the operational airplanes in order to keep this performance lead. We do not consider simply reaching a Mach Number sufficient to obtain useful information for the airplane designer. We find that it is necessary to obtain information up to a practical maximum lift for the configuration at any given Mach Number.

The mission of the program was to investigate all practicable areas. The mission of each specific airplane was to provide quantitative data representative of qualitative pilot evaluation in the stability and control field and measurements not assessable by the pilot. The mission of the research pilot is closely akin to that of the airplane. A development of the capabilities of the airplane is inseparable from the development of the piloting techniques that will adequately present, in the form of recorded data, the characteristics of the particular airplane. The problems besetting the engineers and the pilots in this program are many and very real. The barriers have proved largely psychological. Those like the sound barrier dissolve before systematic probing as the knowledge develops. The problems remain with us much longer. The thermal barrier will be penetrable with the same methods. The barrier that is the enigma yet is the alarmist barrier, which, however, if it does nothing else, serves a purpose in promoting caution.

An NACA pilot's part in the research airplane program follows a general pattern. A new research airplane due at NACA has been flown by the contractor to demonstrate that it will fly and to attest its structural integrity. Occasionally the contractor or the contracting service will do more for their own reasons. The airplane is then turned over to NACA for exhaustive investigation of its capabilities and characteristics and correction of its problems. Upon receiving a research airplane at the High-Speed Flight Station, in fact months before, the project pilot is charged with learning all that he can about the airplane. This entails investigation of the aerodynamic and stability and control characteristics as predicted by analytical study, wind-tunnel investigations, and contractor flight demonstrations. Furthermore, the operational functions and mechanisms of the airplane become as well known as the available information permits. Company pilots and engineers are traditionally, in my experience, extremely eager to help with their experiences. If the contracting service has experience with the airplane, it is added to the accumulation of preflight information. The first

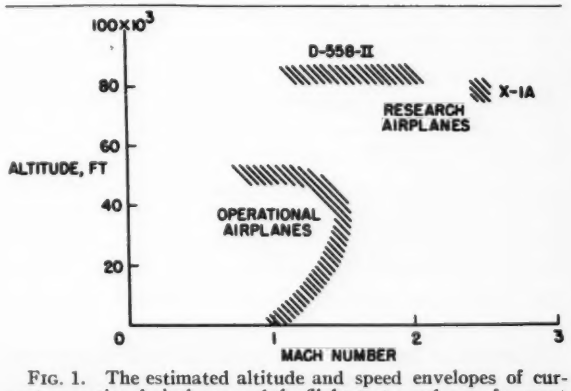


FIG. 1. The estimated altitude and speed envelopes of current operational airplanes and the flight-test envelopes of current research airplanes.

NACA flight of the airplane is devoted, as a rule, to a gross evaluation by the pilot with emphasis on the low-speed and stall characteristics.

From the first flight on, the original program of evaluation is pursued at a rate determined by the results of each succeeding flight in a methodical step by step process. The evaluation program basically is one of detailed investigation of aerodynamic parameters in an ever-expanding envelope of speed and acceleration. Undoubtedly, in such a method, before the extreme limits of the airplane capabilities are reached, many problem areas have to be surpassed. Some of the problems are solved quite satisfactorily. Some, it is decided, have to be lived with, and for others, ways have to be found to fly around the problems that are in the basic nature of the configuration and cannot be eliminated short of building another airplane. Witness the D-558-II, which is an airplane of many problems but whose usefulness has been extended a whole Mach Number beyond the original concept by recognizing the reasons for the problems and, with this knowledge, flying around them. After each flight the pilot must carefully study his methods and approaches to determine as much as possible each step of the next flight, the main objective being to do the next maneuver so that the data obtained are compatible with the previous data or, in some instances, are more useful than the previous data.

Early in the program, before patterns of airplane behavior are wholly apparent, the direction and rate of development lean heavily on pilot observations in data assessment. As the knowledge of the airplane expands, the data usually speak for themselves, with pilot observations complementary. In neither case, regardless of promising extrapolation, are large steps taken as a matter of Station policy. Later stages in the program sometimes find the pilot perplexed by observations apparently not substantiated by the records. Herein lies the crux of some of the most important research findings.

The pilot's biggest problem may lie in asserting unexplained observations against the pressure of expert opinion and quantitative data obtained from oversimplified and unimaginative analytical methods. Of course, the pilot can be in error, too, but the thought provoked by the divergent opinions can be fruitful, and this fact should not be ignored or some phases of research become merely documentation without explanation. The research pilot must arm himself with chronic pessimism for sales resistance. The research pilot must view with alarm the current growing deterioration of stability and control characteristics if he is to discharge honestly his responsibility to operational pilots. His place requires constant vigilance and rigid constancy in resisting reduction in acceptable standards. This is not obstinacy; it is only an effort to maintain balance in a rapidly advancing art.

The rate of acquiring skill in the development of the test techniques is greatly accelerated by candid introspection after each flight, which can be done by the pilot only. While invaluable, postoperative criticism by other interested parties is not necessarily focused on the whole picture. My own method is to report continuously by radio for recording on tape. This tape is sometimes played back several times over for criticism.

As the program expands, isolated observations begin to form patterns. These patterns, sometimes almost unrecognizable, often are the meat of the investigation. At times results come quickly and unexpectedly. A stability behavior acutely observed and exploited upon its occurrence can give many answers in a short time. Occasionally it may be a case that is unsafe to repeat and, hence, represents the total knowledge available.

In many places in the course of this paper the word "pilot" certainly has meant the integrated team of the flight-test analysts, the operational engineer, and the pilot. At the High-Speed Flight Station the three positions overlap so as to differ only in emphasis. Since piloting technique is the subject here, let us look at what the guiding influence is. First recognition is that the research airplane work is the seeking of basic information that can be represented in report form in such manner that it can be applied to the many specific problems of practical mission airplane design. The toughest problem is the presentation of opinion in quantitative form. Newly found nonlinearities, for example, give the lie to accepted numerical limits. The grossest example can be found in the pitch-up characteristics that are found in airplanes with apparently acceptable pitching-moment curves based on degree of stability but not accounting for the second and third derivatives. Accelerations arising from these nonlinearities give the lie to supposedly static data. Another gross example lies in the interpretation of rolling data without regard to the contributory effects of the combination of adverse yaw and high dihedral found in many current configurations. The presentation and the data are not in error; it is, rather, our inability to present the data in a form representative of the physical facts that face the pilot that is the real problem.

The traditional isolation of longitudinal motions and lateral directional motions because of the limitation of analytical methods is not always recognized by the airplane, and we lose the sense of the parameters that come out of the methods. Ratios of motions and phase relationships are appearing more frequently as determining factors between good and poor handling characteristics, even when individual derivatives are well within acceptable values.

A different pilot evaluation problem arises when many effects obscure the attempt to evaluate one characteristic. Buffet evaluation, for instance, is nearly an impossibility from a pilot's standpoint, except with regard to comfort in a particular airplane. The pilot hears and feels intensities; buffet is analyzed with regard to amplitudes. The pilot hears low-intensity second bending and torsional modes and feels the primary modes. The pilot impression is determined by cockpit location, canopy shape, and other airplane sounds. All in all, pilot buffet evaluation is never con-

crete in a quantitative sense. These and several other characteristic evaluation problems influence the quest for research flying techniques.

The development of the pilot with the development of the larger flight envelopes is not a new or surprising thing. It was the matter of first importance in the view of the Wright brothers 50 years ago. Actually, while each decade produces forecasters of the end of pilot limitations, flying over the past 50 years has not begun to outstrip pilot adaptability. The record of safety of the research airplane program attests to this fact. Perhaps the reason lies in the fact that the altitudes have increased the safety factor faster than the speeds have diminished it. Altitude lends safety because of lower aerodynamic loads and increased time allowed for corrective action in case of trouble. We think that the training, engineering support, and the scientific approach to new problems in the face of deteriorating flyability is a dominant factor supporting the pilots.

It seems that the present-day pilot is expected to defend his profession against the encroachment of the robot. I shall indulge briefly in this only because it has become an international sport. To my knowledge the human pilot has not been a detriment to the aeronautical endeavor. Ignoring philosophical support of the pilot, the case has been concisely put technically by S. N. Roscoe[1] as follows: "We will have men in most of our airplanes because men are capable of complex pattern discrimination and perceptual constancy, that mysterious ability that enables us, for example, to see round things as round and square things as square even though we view them obliquely. We will have men in our airplanes because they can respond appropriately to so many different kinds of inputs, because they have such an immense long-term storage capacity from which they can quickly select a program appropriate to the immediate situation, because men can change their own transfer functions, because they contain the equivalent of approximately nine billion binary decision elements, because men are relatively immune to jamming, are reasonably reliable, and relatively easy to maintain. Instead of taking the men out of airplanes we must take maximum advantage of these marvelous abilities possessed by all normal people."

A comical thought comes to mind. If we are capable of creating mechanical servos, capable of accomplishing the complicated skills of flying, then there is little of men's everyday activity that cannot be done by these robots. If that becomes the case, there is little reason why these robots should permit coexistence of men with them on earth except for replacement purposes. But then some ingenious person will design a fraternization circuit, and then the last purpose for our existence will have vanished.

To be sensible, much of the success of the research airplane program, indeed the aeronautical effort, relies heavily upon pilot responsibility. All pilots will give a hearty amen to the thesis that 99 per cent of the problems that face the pilot are in the lack of reliability of the working mechanisms, particularly those of an electrical nature. Any pilot's handbook involves how to work the mechanisms and what to do when they do not work. When a pilot checks out in a new airplane he first asks, "How does it work, and how do I override it if it doesn't work"; and then, "How do I save my life if the malfunction cannot be by-passed." Little is said of pilot ability; much is said of mechanism ability. The statistical possibility of flying a modern airplane with the expectation of 99 per cent of its components working properly during an entire flight is practically nil. Fortunately, pilot responsibility can cover a large proportion of these malfunctions. In a research effort that is stretching the limits of our knowledge and technical ability, a compromise involving more than the absolutely necessary automatic devices is unacceptable. The simpler the airplane can be made, the greater the command the pilot will have in all situations. Complexity is easy, simplicity is an engineering challenge.

A summary of the foregoing ideas may follow in this manner:

(a) The performance, economic, and operational penalties imposed by complexities arising from an underestimation of the pilot unnecessarily restrict our progress.

(b) It must be recognized that each use of our automatic devices presupposes a mathematical certitude in flight that is nonexistent and therefore is necessarily restrictive.

(c) Back to important considerations of this paper, it must be recognized that flight research techniques are inherently bound to our data presentation and interpretation methods, and we must relentlessly search for compatible flight and data presentation techniques.

(d) Data reporting methods must strongly endeavor to present data in the form that represents the physical facts facing the pilot, even to the extent of unique presentations for unique airplanes if conventional methods fail in this respect.

(e) Perhaps most important of all is insatiable curiosity sparked by any discrepancy between data and pilot opinion or deviation from traditional concepts.

Reference

[1] Roscoe, S. N., *Designing the Cockpit for High-Speed Flight*, Aeronautical Engineering Review, Vol. 13, No. 21, pp. 47–51, December, 1954. Also available as IAS Preprint No. 481.

IAS News

(*Continued from page 21*)

invited to speak before the Swiss Federal Institute of Technology in Zurich; the Sorbonne in Paris; the Technical University of Delft, Holland; The Imperial College of Science and Technology in London; and the University of London.

▸ **Lieutenant General Donald L. Putt,** USAF, IAS Honorary Member and Fellow, Deputy Chief of Staff—Development, Air Research and Development Command, has been promoted to the permanent rank of Major General, regular Air Force.

Members on the Move

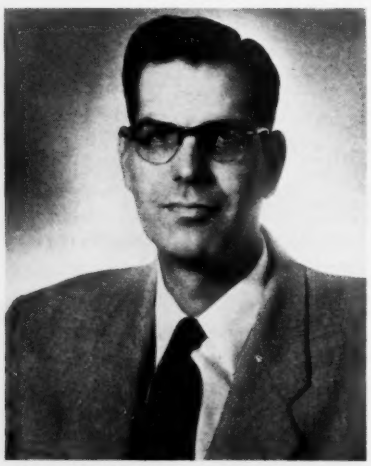
The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are, therefore, urged to notify the News Editor of changes as soon as they occur.

Raymond C. Blaylock (AF), Chief Engineer, Chance Vought Aircraft, Incorporated. Formerly, Assistant Chief Engineer, Chance Vought.

Horace Brock (M), Vice-President, New York Airways, Inc. Formerly, Manager, Atlantic Division, Pan American World Airways, Inc.

Franklyn B. Cole, Jr. (M), Manager, Mechanical Research Department, Lockheed Aircraft Corporation. Formerly, Group Engineer—Controls, Lockheed.

William H. Dammer (TM), Field Service Engineer, Boeing Airplane Company, Lincoln, Neb. Formerly, Field Service Engineer, Boeing, Merced, Calif.



Dr. Millard V. Barton, AFIAS, has joined the staff of The Ramo-Wooldridge Corporation as Engineer in the Guided Missile Division. Dr. Barton was formerly Chairman of the Department of Engineering Mechanics and Research Engineer for the Defense Research Laboratories at the University of Texas.

Harry O. Davis, Jr. (M), Assistant Project Engineer, C-130A Turboprop Cargo Airplane, Georgia Division, Lockheed Aircraft Corporation. Formerly, Assistant Project Engineer, B-47 Project, Georgia Division, Lockheed.

Aram Dervishyan (TM), now with Aerophysics Development Corporation. Formerly, Research Engineer, Engineering Department, University of California.

Fred N. Dickerman (F), Director of Engineering, Chance Vought Aircraft, Incorporated. Formerly, Chief Engineer, Chance Vought.

Oscar W. Dillon, Jr. (TM), Graduate Student, Columbia University. Formerly, Lieutenant, USAF, on Extended Active Duty.

John A. Drake, (M), Director, Long-Range Planning and Research Programs, Marquardt Aircraft Company. Formerly, Chief Engineer—Engines and Afterburners, Marquardt.

Lieutenant Albert C. Durner, USAF (TM), now with 1090th Hq. USAF Spec. Reporting Group, Sandia Base, New Mexico.

Alfred A. Gassner (AF), General Manager, Fairchild Kinetics Division, Fairchild Engine and Airplane Corporation. Formerly, Owner and Chief Engineer, Gassner Aircraft Engineering.

Robert L. Hall (F), Vice-President—Engineering, Grumman Aircraft Engineering Corporation. Formerly, Chief Engineer, Grumman.

Ulrich Haupt (M), now Associate Professor of Aeronautics, U.S. Naval Postgraduate School.

Martin V. Kiebert, Jr. (M), Assistant to Chief Engineer—Technical, Convair Division of General Dynamics Corporation, Pomona, Calif. Formerly, Chief Engineer, P. R. Mallory & Company, Inc.

Captain John W. King, USN (Ret.), Executive Vice-President, Power Generators, Inc. Formerly, Assistant to the President, Stroukoff Aircraft Corporation.

Herbert Kurit (TM), Member, Technical Staff, Aerodynamics Section, Guided Missile Division, Research and Development Laboratories, Hughes Aircraft Company. Formerly, Research Engineer, Electronic Miniaturization Section, Hughes.

Garth C. Ladd (TM), Senior Aerophysics Engineer, Convair-Fort Worth Division of General Dynamics Corporation. Formerly, Research Associate, Department of Aeronautical Engineering, Rensselaer Polytechnic Institute.

Lieutenant Colonel Robert K. Le Beck, USAF (M), Student Officer, Course on "Management of Research and Development," University of Chicago. Formerly, Air Force Plant Representative, Aircraft Engine Division, Ford Motor Company.

Robert L. Mahin (M), Research Engineer, Missile Systems Division, Lockheed Aircraft Corporation. Formerly, General Engineer, U.S. Naval Ordnance Test Station, Pasadena, Calif.

Morris Morduchow (M), Associate Professor of Applied Mathematics, Polytechnic Institute of Brooklyn. Formerly, Assistant Professor of Applied Mathematics, Brooklyn Poly.

Captain Charles H. S. Murphy, USN (M), Commanding Officer, U.S. Naval Special Devices Center, Port Washington, N.Y. Formerly, BuAer Representative, St. Louis, Mo.

Alfred Ritter (M), Staff, Propulsion and Structural Research Department, Armour Research Foundation, Illinois Institute of Technology. Formerly, with Mechanics Branch, Office of Naval Research, Department of the Navy.

W. F. Spurr (M), Superintendent, Marine Aircraft Experimental Establishment, RAF Station, Felixstowe, Suffolk, England. Formerly, Assistant Director, Directorate Aircraft Research and Development, Ministry of Supply, England.

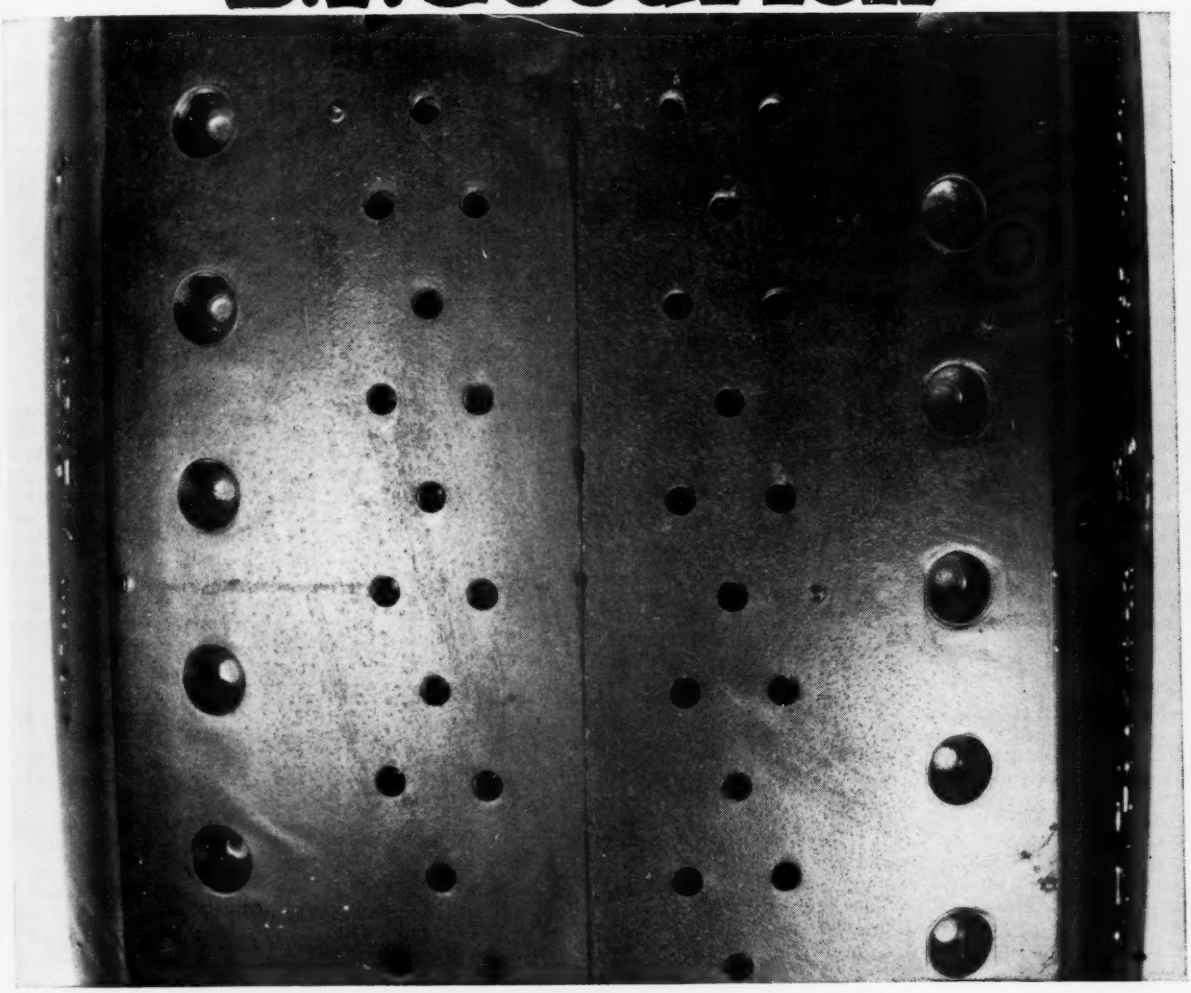
William F. Stoudt (TM), Design Engineer, Helicopter Division, McDonnell Aircraft Corporation. Formerly, Lieutenant, USAF, on Extended Active Duty.

David B. Watson (TM), Aerophysics Engineer, Convair-Fort Worth Division of General Dynamics Corporation. Formerly, Aerodynamic Engineer, Chance Vought Aircraft, Incorporated.

Lieutenant Philip Zove (TM), Project Engineer, Design Aerodynamics Section, Aerodynamics Branch, Directorate of Laboratories, Wright Air Development Center, Wright-Patterson AFB, Ohio. Formerly, with Climatics Unit, Flight and All Weather Testing.

Kenneth B. Turner, TMIAS, has been appointed Technical Director of Cook Electric Company's Plymold Division. Previously Senior Plastics Engineer at Brunswick-Balke-Collender Company, Mr. Turner has been in layout, tool design, and production work with molded plastic laminates for the past 12 years.

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER



New tire puts more rubber to work to give even more landings

STARTING IN 1948, airline after airline put the B. F. Goodrich Dimpled Tire through the most extensive comparison tests. And it outwore all others—sometimes by as much as 27%.

Within 5 years, it was adopted by 24 airlines. The reason: dimple-like indentations resulted in better load distribution throughout a larger tread area. Wear was slower and more even with greater protection against tread cutting. It all added up to more landings before recapping.

Latest development in B. F. Goodrich Dimpled Tires is shown above. It is giving even more landings because it puts even more rubber to work. Dimples are sized, spaced and arranged to give an improved wear pattern. The tread is flatter to give a broader footprint the instant the tire touches the runway. Thus, wear is spread more evenly from shoulder to shoulder. In addition, the tread is made from new, longer-lasting rubber compounds.

Preliminary reports from current airline tests indicate the new B. F. Goodrich Dimpled Tire gives substantially more landings than any other kind of tire.

Although production of this BFG Dimpled Tire is still limited, it will soon be available in most popular sizes.

The new B. F. Goodrich Dimpled Tire is one of many "firsts" in aviation tires from B. F. Goodrich, leader in rubber research and engineering.

Another recent "first" is the famous B. F. Goodrich Tubeless Tire for combat jets. Other BFG products for aviation include wheels and brakes, De-Icers, heated rubber, Pressure Sealing Zippers, Avtrim, inflatable seals, fuel and oil cells, Rivnuts, hose and other accessories. *The B. F. Goodrich Co., Aeronautical Sales, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER

Corporate Member News

• **AiResearch Manufacturing Co., Division of The Garrett Corporation. . .**The Garrett Corporation recently announced immediate plans to construct a $1,000,000, 73,000-sq.ft. addition to the AiResearch Manufacturing plant, adjacent to the Los Angeles International Airport. The new building will house both AiResearch's Engineering Department and Garrett's administration offices.

• **Allis-Chalmers Manufacturing Company. . .**Allis-Chalmers and Consolidated Western Steel Division of United States Steel Corporation have signed a contract with the Tullahoma (Tenn.) District Corps of Engineers, U.S. Army, for the design, procurement, manufacture, and construction of the plenum evacuation system at the Arnold Engineering Development Center. The plenum evacuation system is for the AEDC's propulsion wind tunnel.

• **Aluminum Company of America. . .**A forging press, capable of squeezing aluminum aircraft sections into shape with pressures up to 50,000 tons, has been erected at the Air Force Plant at Alcoa's Cleveland, Ohio, works. This 50,000-ton press and another one with a 35,000-ton capacity are scheduled to go into full production early in 1955.

• **Avien, Inc. . . .**A Remote Position Indication System, now being marketed, indicates the positioning of trim tabs, wing flaps, nose wheel, landing gear, and similar aircraft requirements. This system is available from Avien in single or multiple indications, as well as in special configurations for practically any applications. The Indicator, which is hermetically sealed, requires 1.75 in. of panel space. . . . A change in corporate name from Avien-Knickerbocker, Inc., to Avien, Inc., was recently announced. The company is now engaged solely in the business of design, manufacture, and sale of instruments for aircraft and industrial use; it has therefore terminated the Aviation Engineering Division under which these activities formerly operated. The Textile Division was liquidated during this change.

• **Bendix Aviation Corporation. . .**The Type LPA-70A Magnetic Antenna has been developed by Bendix Radio Division to provide a flush-mounted automatic radio compass antenna with antinoise characteristics for high-speed aircraft. This unit, which measures approximately 17 by 17 by 4 in. and weighs about 8 lbs., may be used with any of the Bendix automatic radio compass equipments. The usable frequency range of the Type LPA-70A Magnetic Antenna extends from below 90 kc. to 1,800 kc. It is supplied for either 100-cycles per sec. or 400-cycles per sec. power sources. . . .A contract has been signed by Bendix and Decca Navigator Company, Ltd., England, whereby Bendix is licensed to manufacture and market Decca Navigator transmitting and receiving equipment in the United States. The Pacific Division started preliminary work for licensed production this past fall. . . . The operations of the Bendix Products Division have been integrated into three sections known as Aircraft Products, Automotive Products, and Missiles. The top position in each of these three sections has been retitled General Manager.

• **Boeing Airplane Company. . .**The one-thousandth B-47 Stratojet to have been manufactured at Boeing's Wichita, Kan., plant was rolled off the line last October 14. No. 1,000 made its appearance just 7 years, 1 month, and 2 days after the original XB-47 came out of the company's Seattle plant.

• **Convair Division of General Dynamics Corporation. . .**A new type of ejection seat, called the "SACseat," has been developed at the Fort Worth plant. According to Convair, this upward-ejection seat has a more foolproof mechanism than most ejection seats now in production. The handgrip and the ejection trigger that fires the canopy are stowed within the body of the SACseat. The crewman cannot fire the ejection trigger until the handgrip is raised to expose it. Dual handgrips and triggers enable the crew member to eject himself by using either hand or both. He can, Convair says, eject himself and the seat from any adjustment position by using only his hand and forearm. . . .A 65-ton milling machine that is capable of handling a piece of metal as big as 10 ft. wide by 30 ft. long has been installed at Convair's Fort Worth plant. It is being used to machine parts for such aircraft as the B-58.

• **Eastern Air Lines, Inc. . . .**The company's passenger terminal facilities at the Miami (Fla.) International Airport have been doubled by the addition of two new wings, each 550 ft. long. These additions, Eastern states, make this the largest passenger terminal operated by any air line in the world. Eastern's enlarged terminal is said to be capable of loading and unloading 19 Super Constellations simultaneously and to have a capacity for more than 2,000,000 passengers a year.

• **Ethyl Corporation. . .**An expansion program involving an expenditure of over $1,000,000 has been announced by the corporation. Major additions are planned at Ethyl's Central Research Laboratories in Detroit and at its manufacturing center in Baton Rouge, La., in order to provide larger facilities for research and development programs.

• **Fairchild Engine & Airplane Corporation. . .**The formation of the Fairchild Kinetics Division from the recently purchased Gassner Aircraft Engineering has been announced. The new division remains at the old Gassner offices at 1860 Broadway, New York City. Alfred A. Gassner, AFIAS, is the General Manager of the Fairchild Kinetics Division.

• **The Garrett Corporation. . .**Permanent eastern headquarters have been established by Garrett at 261 Madison Ave., New York City. This office supervises the operations of Garrett's Air Cruisers Division, Aero Engineering Division, and The Garrett Manufacturing Company of Canada, a subsidiary. It also handles business matters for all other Garrett divisions in connection with their eastern activities.

• **General Electric Company. . .**A new radar height-finder is being made for the Air Force by G-E in mobile and fixed versions. The radar height-finder is being used together with search radar to detect high-flying aircraft and to provide information on distance, altitude, and flight direction. Engineers of G-E's Heavy Military Electronic Equipment Department and of ARDC's Rome Air Development Center, N.Y., collaborated in developing the radar unit. . . . Three new bulletins—GEA-6211, GEA-6212, and GEA-6213—have been announced by the company. GEA-6211 describes a hermetically sealed subminiature relay for

Beech Aircraft Corporation's newest entry in the standard six-place executive aircraft field is the Beechcraft Model C50 Twin-Bonanza. Designed to an 8g flight load safety factor, the C50 has a cruising speed at 10,000 ft. of 200 m.p.h.; its maximum speed is 210 m.p.h. The maximum range at 10,000 ft. and with no reserve fuel is given as 1,100 miles. The airplane has an allowable gross weight of 6,000 lbs. and an empty weight with residual fuel and average radio of 3,960 lbs.

New Turbine-Powered Cargo Carrier

hauls big pay loads faster

Allison T56 Turbo-Prop Engines Power New Lockheed YC-130 Transport

The initial flight of the YC-130 Medium Cargo Transport marks another great forward stride in transport aviation.

This giant carrier, built by Lockheed for the U. S. Air Force, is the first U. S. A. F. cargo plane designed from the very beginning for Turbo-Prop engines.

Powered by four of the new Allison T56 Turbo-Prop engines, this great new cargo airplane can haul heavy pay loads long distances at speeds required by our new modern combat jet Air Force. It is ideally suited to carry many types of heavy military equipment, on either long-range operations or in close support of troops. It also can be fitted as a combat troop carrier or an ambulance plane. The YC-130 can operate from shorter runways with greater rate of climb than either reciprocating or Turbo-Jet engine aircraft.

All this, plus its economical use of lower cost fuel, label the Turbo-Prop engine as the "work horse" power for future transports. And Allison, with its unmatched experience in high-powered Turbo-Prop design and manufacture, today offers both T56 and T40 engines to serve a broad range of modern flight requirements.

GM GENERAL MOTORS Allison Division of General Motors, Indianapolis, Indiana

USN Grumman COUGARS ARE

Alodized

WITH "ALODINE"®

for EXTRA PROTECTION

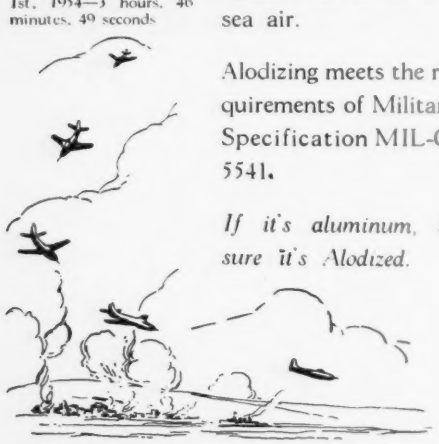
Navy LCdr Francis X. Brady with Cougar, in which he broke transcontinental flight record April 1st, 1954—3 hours, 46 minutes, 49 seconds

The terrific speed of the GRUMMAN Cougar and its severe service requirements make surface protection of its aluminum components a "must." "Alodine" provides a durable paint bond, in addition, it protects the aluminum against corrosion, especially when exposed to sea air.

Alodizing meets the requirements of Military Specification MIL-C-5541.

If it's aluminum, be sure it's Alodized.

Snow-covered Panther Jets on flight deck of USS Philippine Sea prior to take-off.



Panther Jets on run-ways.

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

CHEMICALS ACP PROCESSES

AMBLER, PA.

CHEMICALS ACP PROCESSES

DETROIT, MICH. NILES, CALIF. WINDSOR, ONT.

electronic applications in aircraft, aboard ship, and on portable units. GEA-6212 covers the function and operation of the company's hermetically sealed high-speed polarized relay for electronic applications. GEA-6213 explains the features, performance, and specifications of the hermetically sealed miniature relay, primarily applied in military and civilian aircraft. All three bulletins are available from G-E's Schenectady, N. Y., office.

• **G. M. Giannini & Co., Inc. . . .** A line of hermetically sealed contact relays, bearing the trade name of Magseal Relays, is being produced by Giannini. These relays operate on a principle that, according to the company, lends itself to sealed contact construction and makes possible fast response, high operating speeds, high sensitivity, and low capacitance along with low contact resistance. Single and multiple element units (up to 109 contacts) are available. . . .The company's general offices and Instrument Development Engineering have been moved to new and larger quarters at 918 E. Green St., Pasadena 1, Calif.

• **The Goodyear Tire & Rubber Company, Inc. . . .** The USAF has placed a contract with Goodyear for the production of 24-by-7.7 tubeless tires for the nose wheel of the Republic F-105 fighter. This is the first contract for tubeless airplane tires for the USAF. . . .R. W. Richardson has been named Vice-President—Sales, for Goodyear Aircraft Corporation. Mr. Richardson was formerly Manager of Goodyear Tire and Rubber Company's North Central Division at Chicago.

• **Grumman Aircraft Engineering Corporation. . .** The following administrative changes and appointments have been announced at Grumman: Vice-President E. Clinton Towl to Administrative Vice-President; Robert L. Hall, FIAS, from Chief Engineer to Vice-President—Engineering; William J. Hoffman from Manager of Tools and Methods to Vice-President—Manufacturing Engineering; General Counsel Charles Kingsley to Vice-President and General Counsel; David Rittenhouse from Production Manager to Vice-President—Production; and Assistant Vice-President—Contracts George F. Titterton to Vice-President—Contracts.

• **Hamilton Standard Division, United Aircraft Corporation. . .** The two-story addition to the division's Pneumatics Laboratory doubles the floor space formerly available for pneumatics and houses highly specialized equipment for the development of aircraft air-conditioning and pressurization systems. The new building was scheduled to be in full operation by the end of 1954.

• **Lear Incorporated. . .** The LearCal Division has announced a new product that permits loud-speaker reception with radio receivers designed only for headset operation. The unit, designated as Model 2350, is an amplifying loud speaker that combines in one case a printed circuit transistor amplifier (2 watts of power output) and a high quality speaker. The speaker, which is plugged into the same place used by the headphones, is powered directly from the airplane's electrical system (12 or 24 volts d.c.).

• **Marquardt Aircraft Company. . .**A two-dimensional ram-jet engine to supply helicopters with boost power during take-off and hovering conditions has been announced by the company. This engine, designed for mounting on the tips of the rotor blades, reportedly adds only 4 or 5 lbs. to the weight of the rotor and produces thrust of 40 lbs. at a tip speed of 650 ft. per sec. The engine pops open for use during take-off and hovering and folds away to replace 15 in. of rotor blade at the tip when inoperative. The engine measures $16\frac{1}{2}$ in. in length, $2\frac{1}{2}$ in. in thickness, and 15 in. in span.

• **McDonnell Aircraft Corporation. . .**An advanced all-weather attack fighter is being developed under a Navy contract by McDonnell. This project marks the corporation's first design entrance into the field of attack-type aircraft.

• **Minneapolis-Honeywell Regulator Company. . .**The company has announced the development of the E-10 autopilot that incorporates new concepts of flight path stabilization and control stick steering. It was designed to meet the problems of supersonic flight. The E-10 accomplishes flight path stabilization by controlling such outer loop factors as altitude and Mach Number and by providing response to beam and bombing system signals. This new instrument permits components to be plugged into the plane, removed from it easily, or shifted quickly from one plane to another even under field conditions.

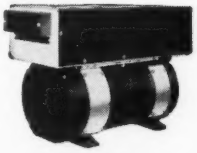
• **North American Aviation, Inc. . . .**The The FJ-4, the latest version of the Navy's Fury jet fighter, made its first flight on October 28. The FJ-4 is powered with a Wright J65-W4 jet engine. . . .A new manufacturing facility is under construction at the company's main plant at Los Angeles International Airport. This $1,200,000 facility, to be designated Building 110, will be used for final assembly, fuselage and wing manufacturing, and electrical subassembly on the F-100 Super Sabre series and for production of future aircraft.

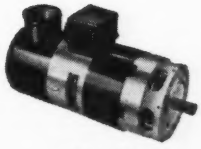
• **The Parker Appliance Company. . .**The company's recently announced aircraft-quality O-ring for hydraulic service has a temperature range of −65° to +300°F. The new rubber material for this O-ring is designated Parker Compound Number 590-5 and was developed by Parker's Rubber Research and Development Laboratory. O-rings will be molded in all standard sizes from this new rubber material. Further information may be obtained from Parker's Rubber Products Division in Cleveland.

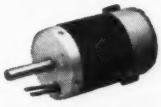
• **Phillips Petroleum Company. . .**In announcements issued by the Atomic Energy Commission and Phillips, it was stated that Phillips is one of nine companies that are members of the recently authorized Rocky Mountain Power Study Group. This group was formed to investigate the technical and economic feasibility of a multiple-purpose nuclear reactor for the production of electrical power, fissionable materials, and radioisotopes. Personnel are contributed to this full-time study group by each of the participating companies, and all expenses of the group's activities are being borne by the companies. As in other study projects, the AEC is making available pertinent reactor

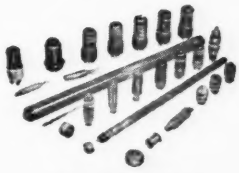
Bendix Red Bank

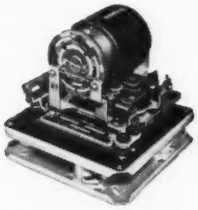
YOUR BEST SOURCE FOR...


INVERTERS


AC—DC GENERATORS


FRACTIONAL H. P. DC MOTORS


SPECIAL-PURPOSE ELECTRON TUBES


VOLTAGE REGULATORS

DYNAMOTORS

With the transfer of carbon pile voltage regulators and AC and DC generators from the Eclipse-Pioneer Division, Teterboro, N. J., the Red Bank Division of Bendix Aviation Corporation is now in better position than ever to serve the aviation industry's needs. When it comes to special-purpose electron tubes, or electrical power equipment of the types shown above, you can be sure of getting top quality from Bendix Red Bank. Our super-modern facilities and highly experienced technical people are always at your disposal. Call on us any time for recommendations.

Bendix Red Bank
EATONTOWN, N. J.

DIVISION OF Bendix AVIATION CORPORATION

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif.
Canadian Distributor: Aviation Electric Ltd., P.O. Box 6102, Montreal, P.Q.
Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

information developed by it and other study groups. The results of the studies of the Rocky Mountain Power Study Group will be furnished to the AEC.

• **Piasecki Helicopter Corporation. . .**Two development contracts have been announced. One of them is concerned with converting the first YH-16 Transporter from piston engines to turbines of considerably higher output than the turbines with which the second YH-16 is being equipped. The other contract is concerned with incorporating engines of higher power in two of the six-place Navy HUP helicopters.

• **Stanley Aviation Corporation. . .**The first F-84F Thunderstreak Cockpit Procedure Trainer has been delivered to the Air Training Command for evaluation. A similar trainer for the T-33A airplane was to have been delivered to the Air Training Command the following month.

• **Thompson Products, Inc. . . .**Kolcast Industries, Inc., with offices and plant at 16601 Euclid Ave., Cleveland, has been acquired by Thompson as a wholly owned subsidiary. Kolcast, producers of frozen mercury castings, particularly large castings for jet aircraft engines, is continuing its same operations under the name Kolcast at its present quarters. All officers and employees continue in their respective jobs.

• **United Air Lines, Inc. . . .**A prototype C-band radar has been installed on the roof of United's Denver Operating Base. The company's Superintendent of Weather Service, Henry T. Harrison—winner of The Robert M. Losey Award for 1953—is currently studying wet and dry snow on the radar's viewing scope located in his office. Scope returns will be correlated with pilot reports of icing in an effort to learn if C-band radar can be used to warn en-route pilots of icing conditions. Tests are also to be made to determine the effects of radome icing on radar performance. United's Board of Directors authorized at a meeting on last August 26 the expenditure of $4,000,000 for installation of C-band radar on 150 of the company's fleet of Mainliners and Cargoliners.

Captain Alfred B. Metsger, USN, speaker at the October 19 meeting of the Cleveland-Akron Section.

IAS Sections

Boston Section

J. B. Tucker, *Secretary*

The first meeting of the 1954–1955 season was held at the Massachusetts Institute of Technology on October 28 at 8:00 p.m. The new Chairman, Joseph J. Jerger, welcomed the members and guests to the first meeting of the season and introduced the new officers.

The guest speaker was Newell N. Davis, Manager of Product Planning, Small Aircraft Engine Department, Aircraft Gas Turbine Division, General Electric Company, who presented an interesting paper entitled "Jet Transportation—Auxiliary Power Systems." The paper dealt with the extraction of airplane power from jet engines, with emphasis on the commercial air-transport type of aircraft. Mr. Davis concentrated on the electrical power requirements, as the problems are similar for both electrical and hydraulic systems and because of the increasing trend toward electrical power. The system problems have become more difficult as the power requirements have increased. Electrical power is currently supplied by a variable speed generator driven directly from a piston engine. As the power requirements grew, it became necessary to go to higher voltage and constant frequency a.c. systems to keep the weight from becoming excessive. In addition, the transition from piston to jet-type engine permitted the possible use of an air-turbine drive. This air-turbine drive utilizes compressor bleed air from the engine and converts it into mechanical power. The air-turbine drive is a complete unit with a lube system, control system, safety device, etc.; hence, it can be located remotely from the engine and supplied by air ducting. The competitive method of supplying power is to mount the constant speed alternator on a variable differential speed drive, which is a turbine mounted directly on the engine.

Mr. Davis compared these two types of drives for the auxiliary power of the jet transport on the basis of different design requirements, performance, equipment weight, flexibility of installation, engine thrust or fuel penalty, and airplane drag and range penalty.

Following Mr. Davis' presentation, there was a brief discussion on air turbines and air-turbine drives. Mr. Jerger adjourned the meeting at approximately 9:30 p.m.

Cleveland-Akron Section

Howard F. Powders, *Secretary*

The October 19 meeting of the Cleveland-Akron Section was held at the Akron plant of Goodyear Aircraft Corporation. Before the meeting got under way, the IAS members and guests were taken on a tour of the Goodyear Aircraft plant and its facilities. After the tour, the group dined as guests of Goodyear Aircraft. The formal meeting began at 8:00 p.m.

The guest speaker for the occasion was Capt. Alfred B. Metsger, USN, Director, Guided Missiles Division, Bureau of Aeronautics, Department of the Navy, who reviewed the progress made in missile development through the years to its present advanced state. He outlined some of the significant trends in missile development which have influenced the weapons of the armed forces and particularly those of the U.S. Navy. Captain Metsger's paper was followed by a short discussion period, at the conclusion of which the meeting was adjourned.

Columbus Section

P. V. Titus, *Secretary*

The following officers of the Columbus Section have been elected for the 1954–1955 season: Chairman, A. Gale Winnett; Vice-Chairman, Dr. John Lee; Secretary, Paul V. Titus; and Treasurer, William Solomon. The Executive Board is composed of David T. Williams, Samuel A. Gordon, George R. Gehrkens, Dr. Rudolph Edse, William J. Meyer, and Morgan M. Blair.

▶ The Columbus Section held its first dinner meeting of the 1954–1955 season at the Officers Club, Naval Air Station, Port Columbus, on the evening of September 29. More than 90 members and guests were present for the dinner.

The speaker of the evening was Darrell C. Romick, Aerophysicist, Goodyear Aircraft Corporation, who spoke on "The Dawn of the Age of Space Travel." The lecture was composed of three main parts: (1) the well-being of the space traveler; (2) the orbital principles upon which space flight will operate; and (3) the methods and devices which will be used to set up and operate a system of space travel.

With regard to the factors affecting the health of space travelers, such important items as the effect of solar and cosmic radiation, meteors, temperature, acceleration, and aerogravity effects were discussed. Mr. Romick stated that many of the problems have already been approached and partially answered in the current effort to pro-

Three officers of the Columbus Section are shown discussing rocketry with Darrell C. Romick, speaker at the September 29 meeting. From *left to right* are: Dr. John Lee, Vice-Chairman; Mr. Romick; Gale Winnett, Chairman; and William Solomon, Treasurer.

tect pilots flying in today's high-altitude research planes. High-altitude rockets and balloons are rapidly accumulating the data required to solve some of the remaining problems.

With the aid of an excellent series of color slides, the portion dealing with orbital principles was simply explained. It was shown how a space satellite would operate and how journeys to the moon, Mars, Venus, and other planets would be planned.

The relative merits and limitations of the basic rocket, the step rocket, and the ferry rocket were discussed. The lecture was concluded with an analysis of the cost and time required to carry out such a program. Mr. Romick stated that the establishment of a satellite would require 10 to 15 years from the time work first begins in earnest and would cost approximately $3,500,000,000. Once the satellite was established, it would serve as a stepping stone to further explorations of space.

▸ On the evening of October 26, Prof. Wilbur Nelson, Chairman of the Department of Aeronautical Engineering, University of Michigan, addressed the Columbus Section on the subject "AGARD—NATO." Being a member of AGARD's Wind Tunnel Panel, Professor Nelson had a great deal of interesting information to present concerning the basic organization of AGARD and the wind-tunnel facilities in the NATO countries.

Detroit Section

H. H. Kerr
Advisory Council Member

The officers for the 1954–1955 season are as follows: Chairman, F. A. Hiersch; Vice-Chairman, A. R. Trahern; Secretary, F. W. Ross; and Treasurer, F. J. Wilhoff. The members of the Advisory Council are: Peter Altman, L. X. Chapin, H. H. Kerr, J. R. Lees, W. C. Nelson, Lawrence Patrick, L. J. Pernick, K. E. Smith, and George Martin.

Hagerstown Section

Andrew Pickens
Secretary-Treasurer

The regular meeting of the Hagerstown Section was held in the Packet Room of the Terrace Restaurant on October 12.

Chairman T. H. Beck opened the meeting with the announcement of the newly appointed committees and some comments on the plans and policies for the coming months.

Our guest speaker, Frederick D. Jewett, was introduced by R. A. Darby. Mr. Jewett, Structures Staff Engineer at The Glenn L. Martin Company, delivered an informal lecture on "Some Characteristics of Structural Adhesive Bonded Joints."

With the aid of prepared stress-strain curves and laboratory test specimens, Mr. Jewett reviewed some of the basic criteria for flush rivet and screw joints and compared these with similar data for bonded joints. Additional curves and diagrams were utilized to touch on the theory of bonded joints and the effect of environmental and curing temperatures on joint strength. Mr. Jewett explained that, because of stress concentrations within the bond, there exists an optimum joint overlap distance; a short joint will have a higher unit shear stress in the glue than one with a much longer lap. Throughout his talk, Mr. Jewett pointed out the need for additional fundamental study of bonding processes.

Following the lecture, the speaker presented a motion picture, *Production Applications of Adhesive Bonding*, which illustrated the methods used in the construction of the Martin B-61 Matador.

The meeting was concluded after a question period. Thirty-five members and guests attended.

Hampton Roads Section

William D. McCauley
Recording Secretary

On November 9, the Hampton Roads Section meeting took place in the Administration Building of the Langley Laboratory of the NACA. Chairman Emanuel Boxer introduced Capt. Sheldon Brown, USN, of the Section Advisory Committee, who in turn introduced the speaker, Capt. J. N. Murphy, USN.

Following graduation from the Naval Academy in 1927, Captain Murphy served with a fighter squadron, was Executive Officer of the U.S.S. "Princeton"; Director, Armament Division, BuAer; Piloted Aircraft Director, BuAer; Commandant, Naval Aircraft Factory, Philadelphia; Assistant Chief of Staff, Fleet Air, Japan, at the start of the Korean war; Commandant, Guided Missile Center, Pt. Mugu, Calif., and is currently Force Material Officer, ComAirLant, Norfolk, Va.

Captain Murphy's 31 years of experience in the Navy enabled him to present his observations on the development and design of aircraft with considerable authority. He stressed the idea of reliability in design. In today's airplanes, the speaker said, parts have been added in such a hurry that often their use is redundant; such is often the case with automatic and manual controls. Some parts may be designed better by decreasing design requirements in favor of system design. Other parts are of a reliable design, but not serviceable. Personnel errors are traceable in many instances to poor engineering design, a prime example of this being the booby-trap type that invites the mechanic to make a mistake. In such cases, it is often hard to see how the mistake could be made, but a simple change in design would have prevented it. There is room for human engineering, the speaker continued, in such things as cockpit arrangement by people who do not overlook details while concentrating on the system. To be of value in detail design analysis, a man with a lot of experience is needed who can detect probable flaws and effectively cure them.

TWIN POCKETSCOPE

by Waterman

Size:
12" x 6" x 7"
16¼ Pounds

MODEL S-15-A

TWO IDENTICAL INDEPENDENT OSCILLOSCOPES WITH COMMON TIME BASE

ANOTHER EXAMPLE OF Waterman PIONEERING...

The WATERMAN TWIN POCKETSCOPE, model S-15-A, presents a new concept in multiple trace oscilloscopy with independent vertical channels each having a sensitivity of 10 millivolts rms/inch, and a response within −2 db from DC to 200 KC—a pulse rise time of 3 microseconds. These features combined with the provisions for intensity modulating either, or both, traces, results in greater flexibility. The sweep generator is operated either in the repetitive or triggered mode from 0.5 cycles to 50 KC with synchronization polarity optional. All attenuators and gain controls are of the non-frequency discriminating type. Remember that portability has not been overlooked! The amazing small size of the S-15-A tips the scales of opinion heavily in its favor. Imagine, all of these essential characteristics in an instrument weighing only 16¼ lbs. You can carry it to any job, anywhere!

WATERMAN PRODUCTS CO., INC.

PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

MEMO... Write for details today!

WATERMAN PRODUCTS

WATERMAN PRODUCTS INCLUDE

S-4-C SAR PULSESCOPE®
S-5-A LAB PULSESCOPE
S-6-A BROADBAND PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE®
S-12-B JANized RAKSCOPE®
S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

At the conclusion of Captain Murphy's talk, members and guests were treated to refreshments.

Indianapolis Section

Ephraim M. Howard, *Member*

The first meeting of the Indianapolis Section was held on October 12. About 130 members and guests were present to hear Bruce Lundin's talk titled "Turbine Engines for Transport Aircraft."

As the Meeting Chairman, Dimitrius Gerdan welcomed the members and guests and briefly outlined the activities leading to the formation of this section. He then introduced Ronald M. Hazen, who presented the speaker.

Mr. Lundin, Chief, Engine Research Division, Lewis Flight Propulsion Laboratory, NACA, apologized for the absence of Abe Silverstein, the paper's coauthor and scheduled speaker for this meeting. The paper, which Mr. Lundin had delivered at the IAS National Turbine-Powered Air Transportation Meeting held last August in Seattle, was well received.

The paper made a comparison of the relative merits of three alternate turbine-engine types for transport work—the turbojet, turboprop, and ducted fan. Inasmuch as most comparative papers encompass only two of these three types, their joint consideration in one paper was quite illuminating. Optimum operating and design considerations were indicated.

A business session followed the talk and subsequent discussion. Mr. Gerdan, acting as directed by a passed motion, selected a Nominating Committee composed of Phillip N. Bright, Allan Stokke, and Prof. Paul E. Stanly. Permanent officers were to be elected at the November 16 meeting from the candidates selected by the Nominating Committee.

Los Angeles Section

Paul R. Strohm, *Chairman*
Student Activities Committee

The First Annual Conference on Aeronautics Related to Education was held at the Institute of the Aeronautical Sciences building in Los Angeles on October 9. This Conference was presented by the California Aviation Education Association and the Institute's Los Angeles Section.

The program was opened with a few words of welcome by Warren A. Dickinson, of Douglas Aircraft Company Inc., Chairman of the Los Angeles Section. Mr. Dickinson expressed the interest of the officers and members of the Los Angeles Section in the Student Activities Committee and outlined the growth and development of the Committee

during the past few years. He stated that the Committee was primarily concerned with the needs of and for aeronautical engineers. This Conference on Aeronautics was arranged to aid educators and schools in handling aviation education and in counseling students who show engineering capabilities as well as related aeronautical interests and to offer the services of Institute members to the schools as speakers and as counselors. It was his desire that this Conference would, as planned, become a continuing activity and enable everyone concerned to become more intimately acquainted with the problems of the schools and to cooperate in their educational programs.

Willis M. Hawkins, of Lockheed Aircraft Corporation's Missile Systems Division, was then introduced by Mr. Dickinson as the "kick-off" speaker for the Conference. Mr. Hawkins outlined the trends toward higher speeds and altitudes, electronic controls, and the new concept that the engineer must design a system and not just an isolated mechanism. Such system design requires more electronic specialists and more research scientists; the industry will require additional engineers and technicians with better training. To illustrate the intricacy of a modern missile, Mr. Hawkins described a vehicle that, after launching, guides itself by celestial navigation to its destination. This example forcefully brought to the group's attention the complex state of development which aeronautics has already reached.

The remainder of the morning session was devoted to a panel discussion on "Educational Requirements for Aeronautical Specialties." Four speakers, each covering a major section of the aviation industry, were introduced in turn by Paul R. Strohm, Chairman of the Student Activities Committee. The first speaker, Clayton C. LaVene, Douglas Aircraft Company, Inc., opened the presentation with a brief description of engineering requirements, with reference to the design and analytical ability of the aeronautical engineer. Robert L. Ehinger, of Northrop Aircraft, Inc., covered the field of flight testing. This included the flight-test engineer and flight-test pilot as well as the air-line pilots and flight engineers. The place of the technician in the aviation industry with emphasis on duties, education, and employment possibilities was covered by C. T. Reid, of Northrop Aeronautical Institute. The final speaker of the morning session was William Bowers, of Cal-Aero Technical Institute, who spoke on the educational requirements for mechanical personnel. He stressed the ever-present need for skilled and qualified mechanics to maintain and repair the aircraft being produced and those to be produced. A short question-and-answer period concluded the panel talks.

Following a chuck wagon lunch at Rand's Roundup, the conference reconvened with Jack Sorenson, of the Civil Air Patrol, discussing the difference between Aviation Education and Aviation Training. Mr. Sorenson emphasized the necessity for the public schools to provide a program of education which stimulates interest in aeronautics and makes the students aware of the influence the airplane exerts on the world of today and of the future.

At this point, the conference separated into three groups for a workshop program. Individual problems of curricula or methods and a presentation of the materials used by each school in their aviation program were the themes of this session. Marshall Benedict, of United Air Lines, Inc., was Chairman of the Elementary Schools Group; the Secondary Schools Group was conducted by Merrill Tower, of Garfield High School; and Miss Shirley Blockie, of Mt. San Antonio College, led the Junior College Group.

The session was closed with a social hour in the IAS Lounge.

Joseph W. Wechsler, *Secretary*

"We have at our command, at the present time, sufficient knowledge to enable us to have the burden of a large fraction of what we do taken over by electronic machinery. We are separated from accomplishing this only by engineering achievements. And the shortage of good systems engineers is the limiting factor in this lack of technical development."

That was the gist of the address delivered by Dr. Simon Ramo, Executive Vice-President of the Ramo-Wooldridge Corporation, at the October 28 dinner meeting of the Los Angeles Section. The address, entitled "Electronics, Thinking Machines, and the Aeronautical Engineer," was attended by over 250 Institute members and guests. Honored guests were Col. Paul Blasingame and Col. Ed Hall, of the Western Development Division of ARDC, and Richard Geer, Chairman of the IAS Student Branch at the University of Southern California. Dr. Ramo was introduced by Dr. Louis G. Dunn, Associate Director of the Guided Missiles Research Division of Ramo-Wooldridge Corporation and until recently Director of the Jet Propulsion Laboratory of the California Institute of Technology. The meeting was presided over by Warren Dickinson, Section Chairman.

Dr. Ramo amplified his theme by reference more to business situations than to technical problems. He did this deliberately in order to emphasize to his engineer audience that potential applications of electronic thinking machines lie in almost every field of human activity. Examples of business applications included inventory control and decisions on product development and manufacture. Electronic gear, applied to inventory control, can monitor closely the many factors that affect the rate at which materials and supplies are used. As a result, smaller inventories can be kept in stock, and the capitalization of the corporation can be reduced. If the savings in interest resulting from greater capitalization are greater than the cost of the electronic inventory control, then the process becomes economically feasible. In the field of deciding, or helping to decide, what product to manufacture, electronic machines can help an executive to consider realistically many more factors affecting the probable success of a venture than would otherwise be possible. This is simply due to the machine's ability to handle enormous amounts of work, even though the type of work may be restricted to a narrow field.

Marvin S. Mixon
Member, Program Committee

At a specialist meeting of the Los Angeles Section held on October 14, Dr. Wolfgang B. Klemperer, Research Engineer with the Douglas Aircraft Company, spoke on "Flight Operations of the Mountain Wave Project."

The speaker discussed the origin of the unusual waves or clouds which form on the lee side of California's High Sierra mountain range. He pointed out that the waves are accompanied by high turbulence and therefore are a hindrance to navigation. For this reason a group has been formed to investigate the phenomenon. The methods employed by the group, primarily the use of soaring planes, were described and illustrated by a silent film in color.

Dr. Jerome L. Fox
Member, Program Committee

"Three-Dimensional Turbulent Boundary-Layer Flows" was the subject of a talk by Dr. Arthur Mager, Engineering Specialist with Marquardt Aircraft Company, at a specialist meeting of the Los Angeles Section on October 26. Attendance at the meeting was 42.

Dr. Mager discussed an approximate method of solution of incompressible turbulent boundary-layer flows in three dimensions. The method is similar to the Kármán momentum integral method. Because of the three dimensionality of the problem, two displacement thicknesses and four momentum thicknesses are introduced. The problem is made amenable to solution by assuming the cross-flow velocity component to be small—i.e., the flow both

KEARFOTT...

from problem through production

Engineering ability and production facilities are as important to you as the characteristics of the components you select. After components are approved, you are dependent upon your supplier . . . dependent upon him for engineering assistance . . . dependent upon his ability to produce quality products in the required quantities.

Many of the servo motors, synchros, gyros and systems in use today had their inception on the drafting boards of Kearfott's engineers. This is proof of Kearfott's engineering ability. Kearfott offers complete engineering service before, during and after the purchase of a component.

A modern building, over 430,000 square feet of floor space, equipped with the latest in precision machinery, manned by 3,000 highly skilled specialists, is your assurance of Kearfott's ability to produce.

Yes, Kearfott is a dependable source of supply. If you have a design problem or require a special or standard component, contact Kearfott.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Send for bulletin giving data of components of interest to you.

Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office: 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

externally and within the boundary layer can be considered to be a perturbation in a known two-dimensional flow. When the method was applied to the case of flow over a yawed infinite wing, it became possible to deduce the independence principle of the main flow and cross flow as first stated by Sears. In addition, it was shown that for angular rotation of not-too-large magnitude about the axis of symmetry no significant three-dimensional effects would result. This reaffirms the conclusions of Schlichting.

Dr. Donald Coles
Member, Program Committee

At a specialist meeting of the Los Angeles Section held on November 2, Dr. Gilles Corcos, Aerodynamicist with Douglas Aircraft Company, Inc., spoke to 50 members and guests on "Turbulent Boundary Layers in Adverse Pressure Gradients."

Dr. Corcos described the point of view and the experimental findings in recent work at The Johns Hopkins University on equilibrium turbulent boundary layers. This research demonstrated that similarity in the mean-velocity profile could be achieved for flows with positive pressure gradient and thus that good pressure recovery could be achieved without danger of separation. In a lively discussion on the floor, there was general, although reluctant, agreement that the similarity properties of equilibrium flows are not readily applied to problems in design as long as the corresponding properties for non-equilibrium flows have not been found.

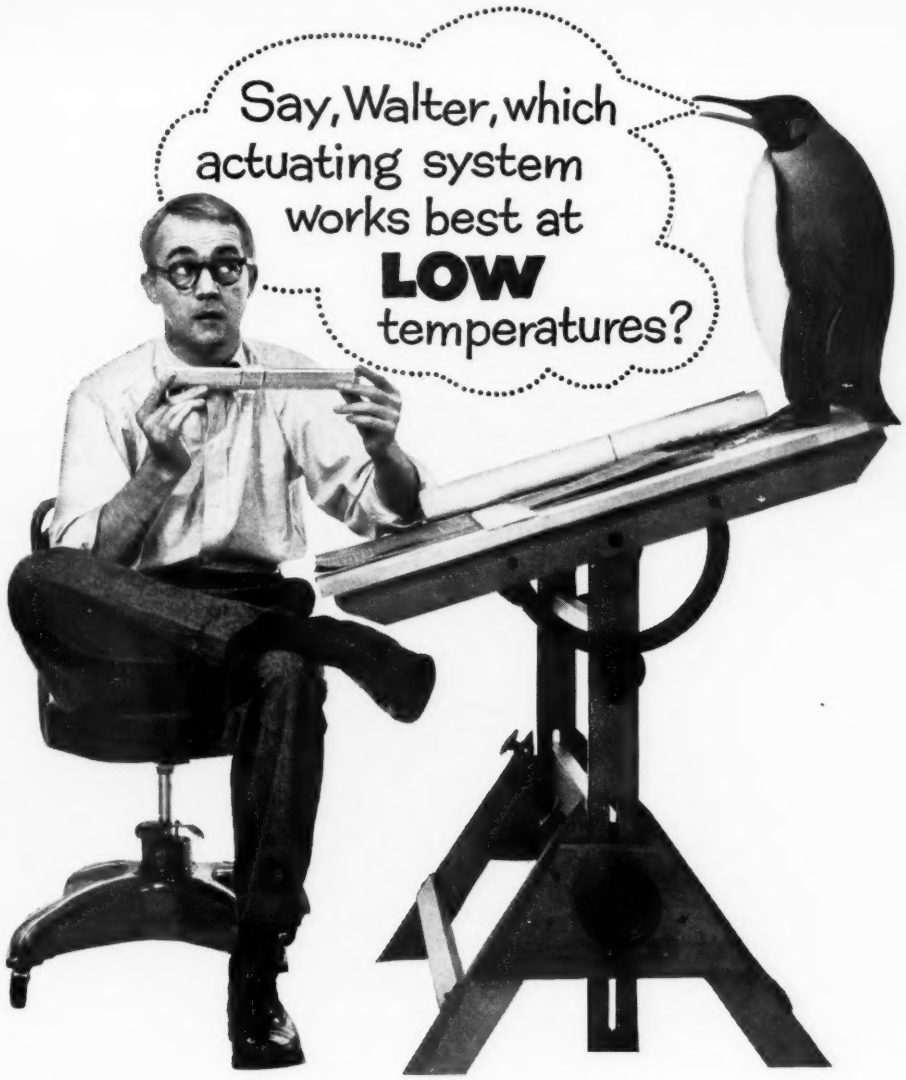
Niagara Frontier Section

George B. Melrose, Jr., *Chairman*

The following officers have been elected for the 1954–1955 season: Chairman, George B. Melrose, Jr.; Vice-Chairman, Robert Goldin; Secretary, Clifford L. Muzzey; and Treasurer, Herbert R. Lawrence. The Advisory Board is made up of William B. Champney, Benson Hamlin, Alexander Krivetsky, and Everett T. Welmers. The Representative to the Area Councilor Nominating Committee is Lester K. Fero.

Clifford L. Muzzey, *Secretary*

The first session of the 1954–1955 season was a joint dinner meeting sponsored by the Niagara Frontier sections of the Institute of the Aeronautical Sciences and the American Rocket Society. Two hundred members and guests attended the meeting on October 13 to hear Dr. Walter R. Dornberger, Missile Design Consultant for Bell Aircraft Corporation, describe travel



For fast, efficient performance at temperatures as low as −65°, consider pneumatics! Viscosity of the air used in pneumatic systems remains essentially the same over an extremely broad temperature range. From −65° to +250°, the system is *never* sluggish.

Only pneumatics *stores* energy and delivers it *instantly* when you need it, with no weight penalty. You get *high* horsepower delivery from a *low* horsepower source, with considerable saving in weight. You also save space, since pneumatic systems use smaller lines, with *no* return lines required.

With pneumatics, there is no danger from fire, since the air used in the system cannot burn. And leakage is no serious problem. Air is always available, and the compressor itself will compensate for any minor leaks which might occur.

We here at Kidde have a *complete* line of pneumatic system components, as well as the facilities for engineering complete pneumatic systems. If *you* have a problem in pneumatics, please write us.

Kidde
FOR PNEUMATICS

The words 'Kidde', 'Lux', and the Kidde seal are trademarks of Walter Kidde & Company, Inc.

Walter Kidde & Company, Inc., 111 Main Street, Belleville 9, N. J. • Walter Kidde & Company of Canada, Ltd., Montreal—Toronto

This picture was taken at the October 13 meeting of the Niagara Frontier Sections of the Institute and the American Rocket Society. From *left to right* are: George B. Melrose, Jr., Chairman, IAS Section; Harry A. Campbell; Dr. Walter R. Dornberger; Willis Sprattling, Jr., Chairman, ARS Section; and Cyril B. Rogers, Program Chairman for the Meeting.

of the future in a talk entitled "Rocket-Powered Commercial Airlines."

Following dinner, the program was opened with greetings from George B. Melrose, Chairman of the IAS Niagara Frontier Section, and from Willis Sprattling, Jr., Chairman of the Niagara Frontier Section of the American Rocket Society. Harry A. Campbell, Chief—General Laboratories, Bell Aircraft, then introduced Dr. Dornberger. Arrangements for the meeting were made under the chairmanship of Cyril B. Rogers, with the assistance of other IAS members of the Program Committee—Herbert Asbury, Frank Keyes, Ivan Rattinger, and John Ryken.

Dr. Dornberger, who proved to be an entertaining speaker, told of his start in rocket technology. No visions of travel to Mars guided his early career; he was ordered by the German Army to become a rocket expert. Subsequently he rose to the rank of Major General and commanded the German experimental rocket station at Peenemunde where he directed experimental work on the V-1 and V-2 weapons. Dr. Dornberger is presently Consultant on Guided Missiles at Bell Aircraft Corporation. He believes that progress from the present-day piston-engine transport airplanes through turboprop, jet, and finally to rocket propulsion will be a slow evolution rather than a revolutionary step. He believes that, while the jump could be accomplished in 10 years with unlimited financial support, the development of rocket transports will probably not be a reality until the turn of the century. He forecast a transport network in which long-range rockets would link the important population centers of the world. For example, he envisioned one rocket port serving the East Coast and one the West Coast of the United States. Smaller distances would probably be covered by other means of flight.

Dr. Dornberger pictured two sizes of two-stage rocket vehicles to cover the range of distances required of a world transport system. Typical size for a 20-passenger, transcontinental vehicle would be approximately 700,000 lbs. at take-off. The fuel and oxidizer would be gasoline and liquid oxygen, with the rocket and its booster section taking off vertically and with all rocket motors burning fuel supplied from the tanks of the booster stage. The boost period would last for 130 sec., during which time the rocket's acceleration would climb from initial value of 1.25*g*'s to 3*g*'s. There would be a momentary return to 1*g* flight while the vehicle separated from its booster, after which the transport would accelerate for an additional 130 sec. reaching a peak acceleration of 3.5*g*'s. Thereafter the craft would continue its flight at about 0.7*g*'s, its speed being great enough at 7,400 m.p.h. to make up the remaining 0.25*g* lift by the centrifugal effect of its curved trajectory around the earth. The flight would start in a vertical direction, and, at the cut-off speed of 7,400 m.p h., the flight path would have curved over toward the horizontal to an angle depending on the required trajectory. Following the cut-off, the rocket would coast and continue to climb to a maximum altitude of 145,000 ft. for the New York-to-San Francisco run, gradually returning to the fully air-borne regime at lower altitudes where the lightly loaded craft would land at a speed of 70 m.p.h. Total time for the transcontinental trip would be $1^1/_2$ hours.

Dr. Dornberger described an imaginary flight from New York to San Francisco with colored slides showing the launching pit, scenes within the rocket's cabin, and the separation phase of the flight with the booster section returning to its base. The passengers would sit in tilted seats that adjust during the flight to accommodate the changing accelerations. The economics of the flight proved to be surprising in that the amount of gasoline required would be only twice the quantity now used by piston-engine airplanes for the same trip. Thus, assuming the cost of the liquid oxygen to be small and neglecting experimental and development costs, flight at the awesome speeds possible with rocket power would be only twice the present cost of air travel.

Seattle Section

Louis Schmidt, *Secretary*

The following officers have been elected to serve during the 1954–1955 year: Chairman, J. E. Barfoot; Vice-Chairman, Lloyd Goodmanson; Secretary, Louis Schmidt; and Treasurer, Norman Bennett.

Texas Section

George C. Grogan, *Secretary*

The annual business session of the Texas Section was held at the September 23 dinner meeting at the Fort Worth International Airport. Prior to relinquishing the Section's reins, Doug Andreoli, the outgoing Section Chairman, reviewed the past year's achievements.

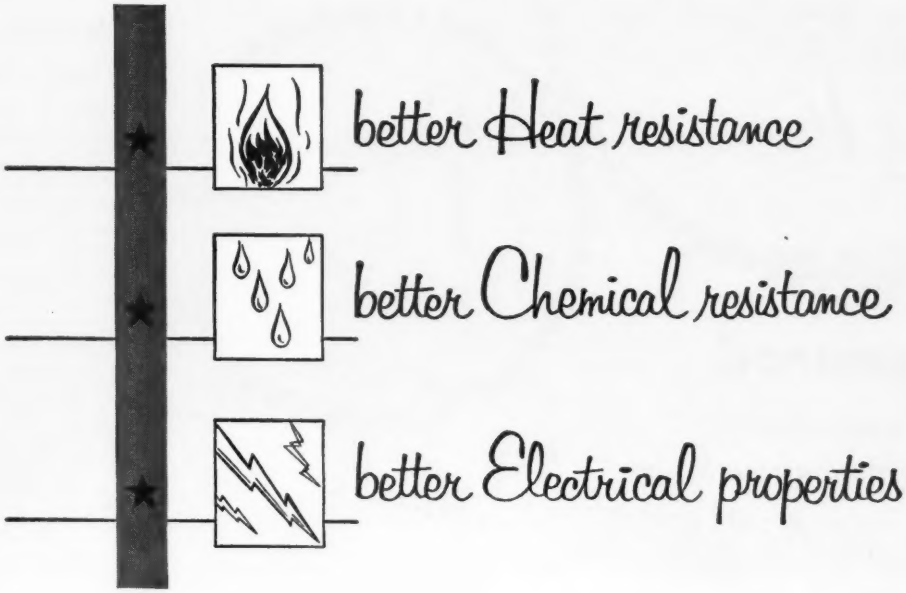
Most pleasant was the disclosure that the Section's membership has increased by 60 per cent and now stands at over 470. Once again, however, the highlight of the year was the Student Competition held in April. Fourteen colleges, represented by both students and faculty members, participated in the competition. The 4-day session had been climaxed by the Awards Night Banquet, which presented J. Lee Atwood, President of both the IAS and North American Aviation, Inc., and Major Charles Yeager, USAF, as the principal speakers.

At the conclusion of the review, the gavel was presented to the Chairman-Elect, Howard Marx. The other new officers were introduced as follows: Vice-Chairman, J. H. Boucher; Secretary, G. C. Grogan; and Treasurer, J. D. Ford.

Guest speaker of the evening was Clifton Younie, Chief Engineer of Braniff Airways, Inc. Mr. Younie listed the chronological steps that would be required to organize, equip, and operate a hypothetical air line. Weaving

Important news!

EPON® resin 828 with new Curing Agent CL gives



If you are among the many users of Epon resin 828 for casting, laminating or other structural applications—you will welcome this new development of Shell Chemical's continuing research program.

Curing Agent CL* produces Epon resin polymers with improved mechanical and electrical properties at temperatures as high as 300° F. After three hours' immersion in boiling water or acetone, glass cloth laminates of Epon resin 828 and Curing Agent CL retained more than 95% of their initial dry flexural strength. And with Curing Agent CL you can use the "B-stage," or pre-curing, process—permitting dry layups and specialized casting techniques.

Your request will bring you a sample of Epon resin 828 and Curing Agent CL for evaluation, as well as a copy of Technical Bulletin SC:54-10. Write for them—today.

Curing Agent CL is Shell Chemical Corporation's name for metaphenylene diamine. We do not manufacture Curing Agent CL. It is available in commercial quantities from E. I. du Pont de Nemours & Company and National Aniline Division, Allied Chemical & Dye Corp.

*A development of Shell Chemical laboratories. Patent applied for.

SHELL CHEMICAL CORPORATION

CHEMICAL PARTNER OF INDUSTRY AND AGRICULTURE

380 Madison Avenue, New York 17, New York

Atlanta • Boston • Chicago • Cleveland • Detroit • Houston • Los Angeles • Newark • New York • San Francisco • St. Louis

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited • Montreal • Toronto • Vancouver

through the myriad of details connected with the administrative, legislative, financial, and engineering problems encountered, the speaker unveiled the complex structure of modern air lines. Those in attendance were left with a deep appreciation of the long road to leadership in commercial carrier operation.

▶ The October 29 dinner meeting was an introduction to the new weapons system concept of water-based and VTO aircraft teams. In a dramatic presentation entitled "Bases Unlimited," Ernest Stout, Staff Engineer of Convair-San Diego, traced the development of this concept.

Following a brief description of postwar hydrodynamic research that yielded the high length-beam ratio hulls and hydroskis essential to modern water-based aircraft, Mr. Stout introduced the team members one by one. First came the R3Y flying boat as the backbone of the team. The R3Y, capable of long-range, high-speed performance, would serve as a cargo-assault infantry carrier capable of direct beach unloading through the bow.

Paired with the R3Y were two new delta-wing fighters—the water-based Sea Dart and XFY-1 VTO aircraft. Serving in fighter-bomber capacities, these aircraft rounded out the weapons system. Requiring no prepared runways and only steel mats and cube docks, the trio presented a highly mobile operating unit equipped with the ability to scramble and disperse in a hurry in the event of enemy attack.

Emphasizing the need to avoid large troop concentrations in an atomic war, Mr. Stout pictured future forward-area assaults performed by a series of these water-based and VTO teams. Slides depicting artists' conceptions of these operations were shown, as was a short colored movie of the XFY-1 in hovering flight.

Full impact of the concept was felt by the audience, especially by those present who had engaged in "island hopping" during World War II.

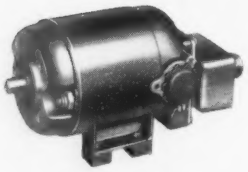
geared

to work closely with your engineers on motor-driven products

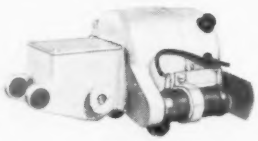
We work so closely with customers that some consider our facilities a part of their own operations.

Close cooperation of our staff with your purchasing and engineering departments assures the right motor for your product.

This can mean improved product appearance, reduced weight, greater compactness and lower costs.



Aircraft de-icing pump motor.



Gear motor for slow-speed drive.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Washington Section

R. Fabian Goranson, *Secretary*

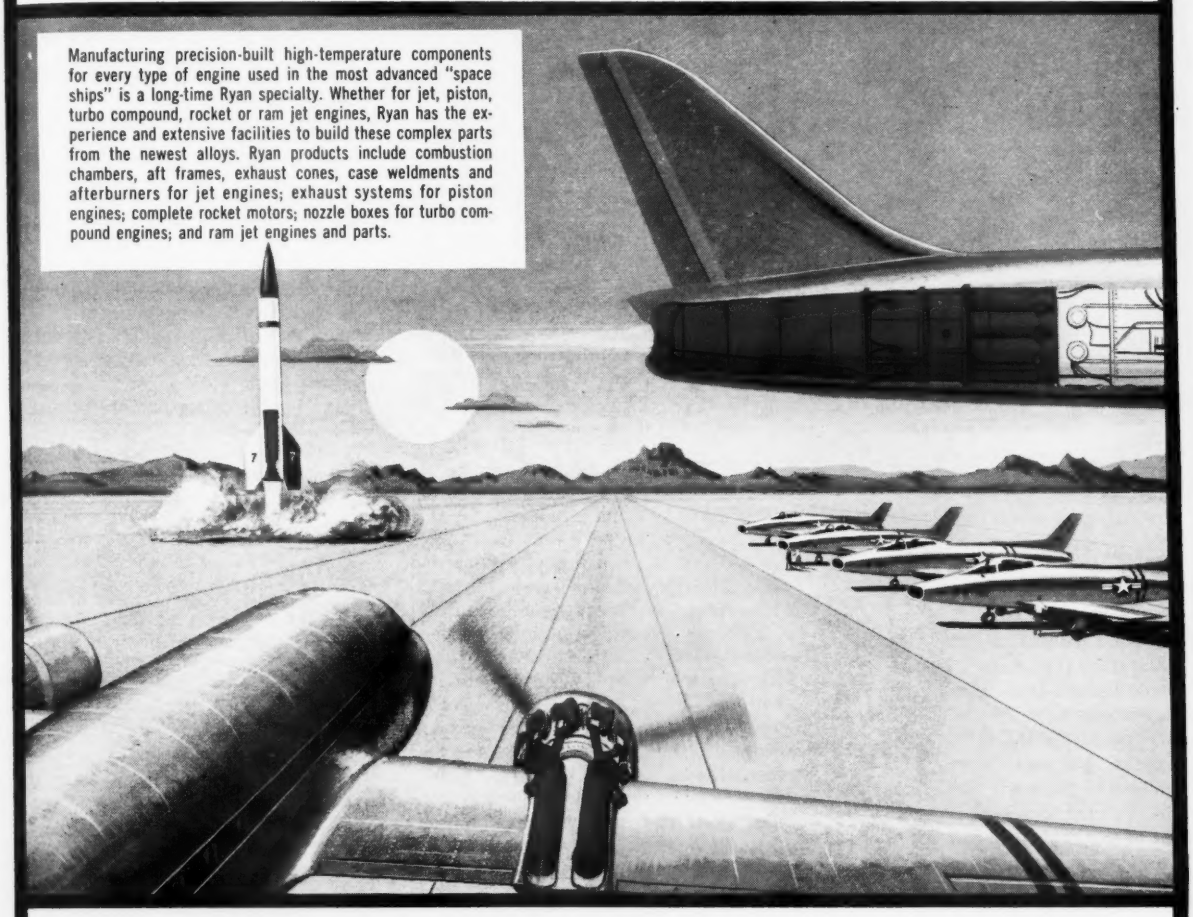
The opening meeting for 1954–1955 was held on October 26 and was devoted to reminiscing and listening to personal experiences of men who have helped make aviation history. Under the guidance of Paul A. Garber, Curator of the National Air Museum, the meeting was started by an inspection of historical airplanes in the custody of the Smithsonian Institution. Particular interest was, of course, displayed in the Wright brothers' airplane, the first airplane procured by the Army Air Corps, the Spirit of St. Louis, Wiley Post's Winnie Mae, and the Bell X-1.

The first airplane procured by the Army Air Corps was of special interest because it was in this airplane that one of the speakers, Brig. Gen. Frank P. Lahm, USA (Ret.), was taught to fly by the Wright brothers. Being one of the few living men to be associated intimately with the beginnings of aviation, General Lahm recalled many personal experiences that interested the audience. He gave a graphic description of how he first learned of the dangers involved in stalling an airplane, an experience that he survived probably only because the airplane dived into a mudhole. Perhaps the most surprising message that General Lahm conveyed to the younger members of his audience was the importance of French efforts in carrying out early experiments in aviation. While giving complete credit to the Wright brothers for being the leaders in the aeronautical movement, he showed clearly how the enthusiasm of French aeronauts contributed materially to aviation progress as well as the much needed moral support for the Wright brothers.

The second speaker of the evening, Col. Bernt Balchen, USAF, reviewed an era of aviation more familiar to the present generation than that discussed by General Lahm. Nevertheless, Colo-

HOT PARTS for "SPACE SHIPS"

Manufacturing precision-built high-temperature components for every type of engine used in the most advanced "space ships" is a long-time Ryan specialty. Whether for jet, piston, turbo compound, rocket or ram jet engines, Ryan has the experience and extensive facilities to build these complex parts from the newest alloys. Ryan products include combustion chambers, aft frames, exhaust cones, case weldments and afterburners for jet engines; exhaust systems for piston engines; complete rocket motors; nozzle boxes for turbo compound engines; and ram jet engines and parts.



Another Example of How

RYAN BUILDS BETTER

For complex aircraft engine components which must withstand searing temperatures, yet be built to jewel-like precision, leading engine makers have come to depend on Ryan—not only for production of current models, but also for development and initial manufacture of vital components of the most advanced design for power plants of the newest type.

Ryan's long and outstanding success as a designer and volume producer of aircraft and aeronautical products has been based on the ability to blend experience, skilled manpower and modern manufacturing methods into products supreme in quality, efficiently produced, delivered on time, and followed up by competent "after sale" service.

For 32 years Ryan has been in the forefront of aeronautical progress. It is uniquely equipped to solve the challenging research, engineering and production tasks associated with building, for America, the world's finest aircraft.

AIRCRAFT & COMPONENTS | AIRBORNE ELECTRONICS EQUIPMENT | METALLURGICAL ENGINEERING | WEAPONS SYSTEMS

RYAN AERONAUTICAL COMPANY SAN DIEGO 12, CALIFORNIA

AFTERBURNERS & JET COMPONENTS | PILOTLESS JET AIRCRAFT | ROCKET MOTORS & RAM JETS | AIRCRAFT EXHAUST & DUCTING SYSTEMS

Shown from *left to right* during the October 26 meeting of the Washington Section are: Col. Bernt Balchen, USAF; Paul A. Garber; Brig. Gen. Frank P. Lahm, USA (Ret.); Brig. Gen. Benjamin S. Kelsey, USAF; and Major Arthur Murray, USAF.

nel Balchen added to a historical chronology of aviation events many of his personal experiences with individuals active in aviation in the period between the end of World War I and the middle 1930's. In particular, Colonel Balchen pointed to the importance of early transpolar flights and aerial expeditions of the polar regions. In view of recent trends toward both military and commercial operation in this area, the importance of the flights by these aerial pioneers becomes more and more significant. Perhaps the key message that Colonel Balchen presented was that of the important role that Charles A. Lindbergh played in encouraging development of aviation in the United States. He was able to accomplish this not only because he was a world hero as a result of his transatlantic flight but also because of his intensive efforts to bring a personal message to the American people by his extensive tours and lectures. Over a period of 3 months he visited a total of 82 cities in the 48 states to convey his enthusiasm for aviation to all who came to see and hear him.

The evening's program was concluded with a discussion by Major Arthur Murray, holder of a world's altitude record, of his experiences with flying the supersonic research airplanes. He reviewed the importance of psychological factors connected with flying at extreme altitudes and extreme speeds and commented particularly on the effects of detail design of airplanes on the feasibility of accomplishing such flight. He also pointed out briefly how recent flights are proving that some of our theories pertaining to weather and atmospheric conditions at high altitudes are wrong and, therefore, need to be revised. He concluded by suggesting that, while we all look upon supersonic flight as an everyday accomplishment, it would be worth while to stop and consider at times how really difficult it was to achieve the first supersonic flight.

Student Branches

Academy of Aeronautics

John A. Hope
Corresponding Secretary

On October 19, 46 Student Members of the IAS and 50 members of the SAE chapter at the Academy participated in a most instructive tour of the Sikorsky Aircraft Division of United Aircraft Corporation in Bridgeport, Conn.

After signing the register, we were divided into groups of ten and conducted through the plant by members of the engineering personnel. Each group upon entering the plant was given a brief lecture on company policy toward such visiting groups as ours. We were then taken around the assembly line of the helicopter plant where we witnessed the assembly of the S-55 model that was destined for military, commercial, and foreign markets. The fully articulated rotor head, of which they are quite proud, was fully explained to us by competent personnel. The many design problems that arise during the manufacture of an aircraft of this type were further explained as we proceeded along the production line to where the finishing touches were being put on the completed models. From the assembly line we were ushered onto the flight-testing line where all new 'copters are put to the test before being released for sale. On the flight line we saw several types, including the new gas-turbine-powered model that recently set a new speed record. Tests were also being conducted on the new twin-engined single-rotor 40-passenger S-59 that they hope will someday replace the DC-3 in the commercial air lines.

The final part of our tour brought us to the Rotor Blade Department, which proved to be interesting as well as informative. We arrived in time to see a blade being tested for balance; each blade that leaves the shop may be interchanged with any other one because of exacting tests. The balance is achieved by careful manufacture. All blades are then placed on a test rig where they are rotated and given various pitch variations to see how closely the blade tips line up with each other.

The tour will long be remembered as educational as well as enjoyable.

California State Polytechnic College

Robert Evans
Student Branch Reporter

The first meeting of the 1954–1955 school year of the Student Branch of the Institute of the Aeronautical Sciences of California State Polytechnic College was called to order by Chairman Jack Gresham on October 7. Eighty-five persons were in attendance.

Chairman Gresham introduced E. W. Robischon, IAS Western Region Manager, who gave a talk entitled "The Background of the IAS." He stressed the "who, why, when, where, and how" of the IAS and its function.

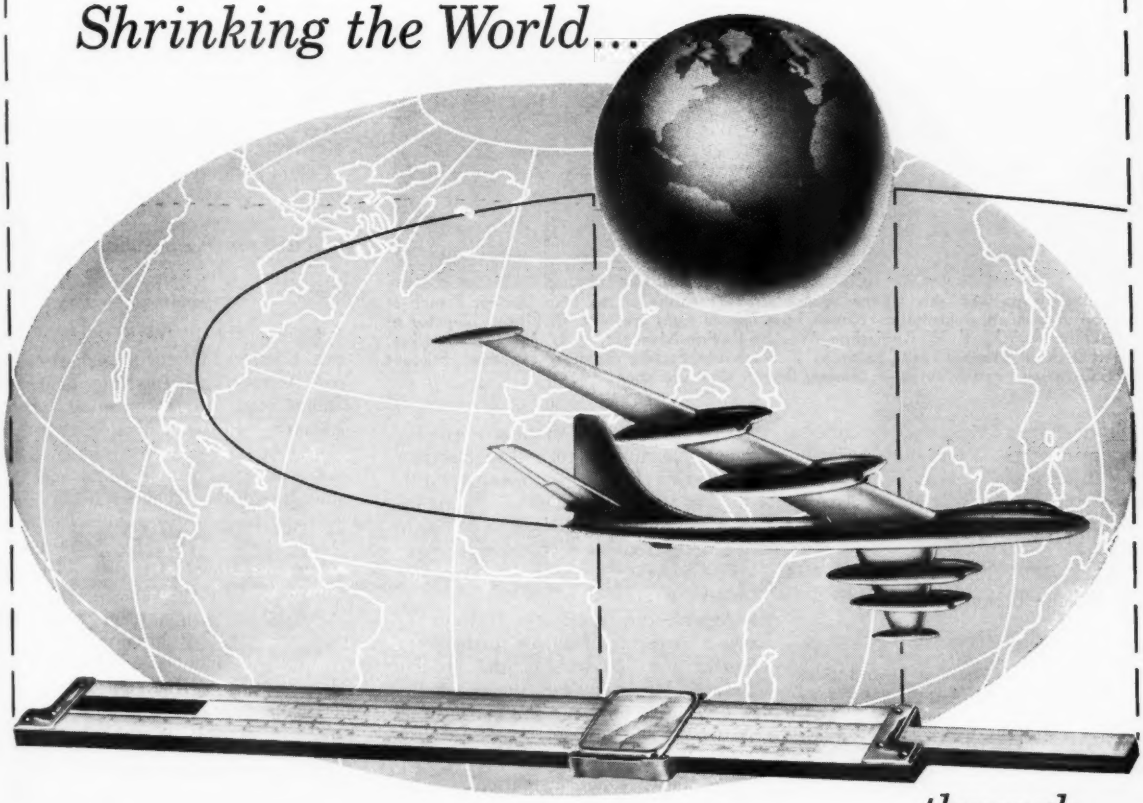
Mr. Robischon's talk was followed by two films—*New Wings for the Navy* and *The Douglas Skyrocket and Landings of AD's on the Valley Forge*. Both films were from Douglas Aircraft Company, the former showing several Douglas-built research planes and the latter showing the drop tests of the D558-II.

▶ The October 21 meeting of the California State Polytechnic College Student Branch was called to order by Chairman Gresham with 50 in attendance.

After a short business meeting, Chairman Gresham introduced Robert Rendall, recently of North American Aviation, Inc., and now a member of the faculty of the Aeronautical Engineering Department, California State Polytechnic College. Mr. Rendall spoke on "The Beginning Engineer in Big Industry." He related the process by which the newcomer would be started and would progress in the engineering division of a large company such as North American.

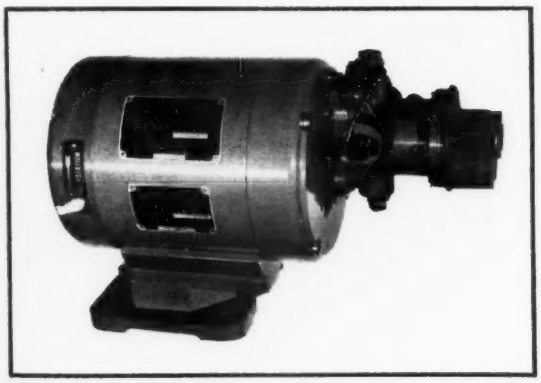
Two movies were shown—*Horizons Unlimited* and *This Is Air Power*. Both were from North American Aviation.

Shrinking the World...



through

Aeronautical Engineering



If it calls for CREATIVE ENGINEERING *... call for ADEL!*

Just how far flight of the future will go beyond present limitations of altitude, speed and distance surpasses imagination. New records are being made with constant regularity, giving us a clue to the startling developments that lie ahead for all types of aircraft—military, commercial and civilian. Research, advanced engineering, design, development and sound production, *which distinguish ADEL products,* will provide major contributions for these new and greater achievements.

A typical example is the high pressure, motor driven hydraulic pump shown here—completely "*ADEL*—Engineered" now in production for current aircraft applications. It is but one of the many units *ADEL* has been called upon to engineer, develop and produce in record time for the aircraft industry—another step in the continuing program of "shrinking the world."

Write for descriptive Brochure containing detailed information on ADEL's *line of Aircraft Equipment and facilities*

ADEL

Precision
Engineered Equipment
for Aircraft

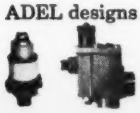
A DIVISION OF GENERAL METALS CORPORATION

BURBANK, CALIFORNIA • HUNTINGTON, WEST VIRGINIA

CANADA: RAILWAY & POWER ENGINEERING CORPORATION, LIMITED

ADEL designs and manufactures aircraft accessories in the following major categories:

HYDRAULIC & PNEUMATIC CONTROL EQUIPMENT



ANTI-ICING, HEATER & FUEL SYSTEM EQUIPMENT

ENGINE ACCESSORIES

LINE SUPPORTS

This photograph was taken at the September 25 meeting of the IAS Student Branch at Northrop Aeronautical Institute. Shown from *left to right* are: H. R. Filson, Director of Engineering, N.A.I.; E. W. Robischon, Western Region Manager, IAS; J. Dallas, Speaker, Aircraft Division, Hughes Tool Company; F. Washburn, Faculty Adviser; H. Emigh, Student Branch Chairman; and K. Neiman, Student Branch Vice-Chairman.

The former showed missiles and missile development projects and facilities owned by North American. The latter demonstrated several of North American's products—e.g., T-28, F-86, F-86D, and F-51.

Indiana Technical College

Bernard E. Heyl, *Secretary*

The meetings of October 14 and 28 of this Branch were attended by 46 Student Members and associates. Chairman John Wright presided on each occasion.

Plans were made for a field trip to the NACA Laboratories in Cleveland, Ohio. A 3:00 a.m. departure time was set to allow a full tour of the installation.

Student Member Kerns Rowe formed a committee to encourage interest in a proposed aircraft design. The consensus limited the physical structure to a low-wing, single-engined, two-seater plane. Entries in the contest being held locally are being accepted by Mr. Rowe and his group.

Movies for the two meetings included *Operation Airborne*, by Douglas, a report on the C-124; *Miscellaneous Views of All-Wing Aircraft*, by Northrop; the *F-86, The Continental Defender*, by North American; and Bell's *Flight Report, X-1A*.

Kansas State College

Gary Hylton
Secretary-Treasurer

On October 7, Chairman Forrest Funk opened the first meeting of the school year and extended a welcome to the old members and visitors present. He then briefly explained the purposes of the IAS.

The guest speaker, Prof. J. W. Shupe of the Applied Mechanics Department, spoke of his experiences over the past $1\frac{1}{2}$ years while employed at Convair in the Stress Analysis Section of the San Diego plant. He discussed employment opportunities for college graduates in the aircraft industry and outlined the steps in the development of an airplane. His talk was highlighted with many anecdotes from his personal experiences.

An interesting discussion period followed the talk.

▶ At a meeting on October 21, ways and means were discussed for further publicizing the activities of the Student Branch. In particular, the possibility of occasional joint meetings with other groups was discussed.

The Faculty Adviser, Prof. F. J. McCormick, called attention to the Branch Awards that are available to active participants in the local organization. He also urged that students begin plans for papers in anticipation of the spring competitions.

Vice-Chairman E. W. Rhoades presented an interesting short paper in which he reviewed the need for more efficient cockpit design. He pointed out that many disastrous accidents have been attributed to "pilot error," but that many of these errors could have been avoided had more thought been given to cockpit design.

Mississippi State College

Charles J. Dixon
Corresponding Secretary

The IAS Student Branch at Mississippi State College started the 1954 fall semester on Septembr 29 with a film entitled *Smoke Trail Movies*, made by Dr. A. M. Lippisch, Head of the Aeronautical Research Laboratory at Collins Radio Company. The film showed experimental work with smoke trails over delta- and rectangular-wing configurations and was both interesting and educational.

At the same meeting, new officers were elected. Earl Bailey was elected Chairman; Thomas Dunning, Vice-Chairman; Thomas B. Burkett, Treasurer; and Charles J. Dixon, Secretary.

▶ On October 14 a meeting was held, and our new Chairman, Earl Bailey, presided. A Program Committee was organized to secure speakers for future meetings. Also, a Membership Committee was organized for the recruiting of new members.

Last of all, but certainly not least, it was decided to have a party. The first attempt was rained out, but as of this writing the fun is yet to come.

Northrop Aeronautical Institute

Charles E. Cook
Corresponding Secretary

Members of the Institute of Aeronautical Sciences Student Branch at Northrop Aeronautical Institute held their annual fall dinner meeting at the Alondra Club, Lawndale, Calif., on September 25. After enjoying a delicious steak dinner, students and their guests were privileged to hear a stimulating and provocative talk by James Dallas, Head of the Electrical Equipment Laboratory at Hughes Tool Company's Aircraft Division.

Among the 50 present at the meeting were E. W. Robischon, Manager, Western Regional Office of the IAS, and Mrs. Robischon; H. R. Filson, Director of Engineering, Northrop Aeronautical Institute; Frank Washburn, Faculty Adviser of the Student Branch; retiring and incoming Student Officers; and Student Members of the IAS and their wives.

Opening his talk, Mr. Dallas assured the members that the future of aviation is a bright one. The young aeronautical engineering student, Mr. Dallas said, will play a major role in the future achievements in aviation. However, he warned that the student should not feel that he is necessarily prepared to accomplish these tasks simply because he has completed a course in aeronautical engineering. He quoted Charles F. Kettering, of General Motors Corporation, as saying that 70 per cent of an engineer's education comes from actual experience and 30 per cent from formal schooling. Mr. Dallas is of the opinion that after several years of practical experience and a continued study program at night, the graduate of a 2-year technical institute such as Northrop is as well qualified as the average university graduate.

Mr. Dallas then described what he feels to be some of the major problems facing the aircraft industry today. First, he stated that we are in danger of creating such a complex airplane that the problems of maintenance would become monumental and that the chances of malfunction would be increased many times. Second, Mr. Dallas said, we need to be more concerned with reli-

BLEED AIR REQUIREMENT

Of particular interest is the way the twin turbine configuration of Hydro-Aire's new Frijadrive System allows the individual optimizing of the refrigeration turbine while tailoring the other turbine to best performance throughout the power requirement range. By utilizing two turbines instead of one, optimum design for refrigeration needs is not compromised for variable power outputs.

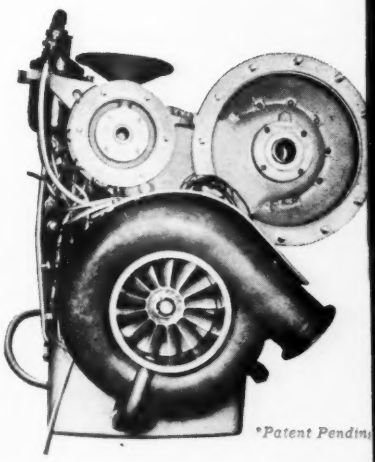
Works both ways: Conversely, additional power demand is not penalized by energy losses from: (1) loss through Heat Exchanger (only the refrigeration turbine is coupled to the Heat Exchanger): (2) increased back pressure from cabin (power turbine exhaust goes overboard).

Net efficiency increased: The advantages, in both weight saved and lower demands on bleed air, are obvious. "We believe Hydro-Aire has made another remarkable contribution to turbine application," states H. H. Rhoads, President.

"Twin Turbine Teamwork"

–a New Principle in the ATM Field!

Frijadrive*



*Patent Pendin

A SINGLE PACKAGE, COMBINING AIR CONDITIONING AND ACCESSORY DRIVE FUNCTIONS

FRIJADRIVE offers weight savings of 20% to 40% and saves up to 50% in bleed air requirements. It is based on an entirely new principle: Twin Turbine Teamwork.

This principle provides speed control within two-tenths of one percent. Accessory power requirements can vary from zero to maximum horsepower. At the same time it supplies a constant air conditioning flow to the cabin.

A control system compensates each of the two turbines as required, thus automatically giving optimum efficiency at all times for both air-conditioning and accessory-drive functions.

We'll be most happy to meet with you and show you exactly how it's done . . . and what FRIJADRIVE can do for YOU. Call, wire or write for the complete story NOW.

Every fighter, every bombe every transport, is Hydro-Aire equipped.

HYDRO-AIRE Inc.

3000 WINONA AVENUE, BURBANK, CALIF

The Aviation Subsidiary of CRANE C

ability. Mr. Dallas, who visited Great Britain in the spring of 1954 as a member of the Air Force Advisory Staff, was impressed by the reliability being achieved by British aeronautical engineers. He feels that we need to do more testing and development work to ensure that our aircraft have the necessary degree of reliability. While Americans lead the world in knowing how to mass produce, we must remember that the reliability of a missile sent to destroy an enemy bomber is of vital importance.

Mr. Dallas concluded his talk with some general suggestions for the "beginning" engineer. He emphasized the fact that the engineer needs to be concerned with economy as well as engineering theory. He stated that in his department at Hughes the engineers are required to make time and cost estimates at the outset of a new project. He urged them to maintain an active interest in the various technical organizations. He reminded the students that the most important task of the engineer is to communicate his ideas clearly and effectively to his associates, whether it is by engineering drawings, technical reports, or the spoken word.

Harold Emigh, Student Chairman of the Northrop Branch, closed the meeting by introducing the new Student Officers. They are: K. D. Reed, Student Chairman; I. Wong, Vice-Chairman; G. B. Sellers, Treasurer; E. Gibson, Corresponding Secretary; and A. M. Donaldson, Recording Secretary. The outgoing officers are: H. Emigh, Chairman; K. Neiman, Vice-Chairman; A. M. Donaldson, Treasurer; C. E. Cook, Corresponding Secretary; and H. Roper, Recording Secretary.

The Ohio State University

William E. Wagner
Secretary

The Ohio State University Student Branch of the Institute of the Aeronautical Sciences held its second monthly meeting at 7:30 p.m. on Tuesday, November 2.

James Detweiler, of Lockheed Aircraft Corporation, was the guest speaker. He was graduated from The Ohio State University in Mechanical Engineering in 1935. He was associated with General Motors Corporation for some time before going to Lockheed, where he has been for the past 11 years. He is now Group Engineer for hydraulic research.

As part of his program, Mr. Detweiler showed some films of actual development programs at Lockheed during the past few years. One of these films, *Aeroelastic Problems*, was about progress and development in wing structures for pilotless aircraft. Another picture, *Operation Breakthrough*, was about tests performed on ejection of the pilot through the canopy of an F-94C Starfire.

Following the movies, Mr. Detweiler gave a demonstration on Lockfoam, a revolutionary plastic filler used as a reinforcing core for aircraft control surfaces.

A question-and-answer forum was then held with questions being asked about everything from air-frame activity at Lockheed to California "smog."

Polytechnic Institute of Brooklyn

Murray Rosenberg
Secretary

On October 9, 60 members of the Brooklyn Polytechnic Student Branch of the Institute of the Aeronautical Sciences made a field trip to Polytechnic's Supersonic Aerodynamics Laboratory at Freeport, L.I.

Dr. Nicholas J. Hoff, Head of the Aeronautical Engineering Department at Polytechnic, announced the opening of the Laboratory late this past summer. It is now under the directorship of Dr. Antonio Ferri, one of the best-known men in the field.

The students were shown the three supersonic blow-down tunnels of the facility by Dr. Paul A. Libby, one of the leading members of the staff. The first two tunnels viewed were capable of producing air flows of up to Mach 5, having test sections 10 in. and 12 in. square, respectively. The latter is currently being used in the problem of mixing supersonic and subsonic flows.

The third tunnel, which is nearing completion, is in the hypersonic class and will produce flows of Mach 20 in its 12- by 12-in. test section. From a reservoir of 2,800 cu.ft. at 2,000 lbs. per sq.in., the air is sent to a spherical convection heater where its temperature rises to 2,000° Rankine at constant pressure. Next, it is sent to the 80-ft.-high cylindrical compression heater where a floating piston, powered by a 3,000-lb. per sq.in. compressed air bank, raises the air to nearly 3,000 lbs. per sq.in. and 5,000° Rankine. The downstream end of the test section is connected to a 35-ft.-diameter vacuum sphere.

▶ The members of the Brooklyn Polytechnic Student Branch visited the NACA Langley Aeronautical Laboratory at Langley Field, Va., on November 1.

The 20 students under the chairmanship of Louis V. Divone arrived by car early Monday morning and were guided on a well-planned and well-executed tour of the Research Laboratory.

After a preliminary talk and a film showing the aims and work of NACA, the group was shown an actual test in the vertical spin tunnel, where the staff demonstrated the effect of stabilizer position on the spin recovery characteristics.

Three other wind tunnels of the NACA were then toured; a supersonic tunnel with a 1,000,000-cu.ft. reservoir capable of speeds twice the speed of sound; and two 7- by 10-ft. test section tunnels with a 700 m.p.h. speed range, where the students were allowed to enter the tunnel itself and inspect the internal details.

In the Aircraft Structures Department, tests were viewed on the new type "waffle-plate" sheets to be used in modern high-speed aircraft.

Also viewed was the Flight Test Hangar where the students inspected many of the new jet planes on which tests were being performed.

Most impressive of all was the full-scale wind tunnel, with a 30- by 60-ft. test section, in which full-sized aircraft and helicopters may be placed.

The facility also boasts its own precision machine shop, where test models are made to close tolerances.

The members agreed that they had learned a great deal from this informative trip and were pleased to view the work that Brooklyn Poly is doing.

Princeton University

Roger D. Carter
Secretary and Treasurer

Our new officers at the Princeton University Student Branch of the Institute for the school year of 1954–1955 are: Richard Batt, Chairman; Donald Wyman, Vice-Chairman; and Roger Carter, Secretary-Treasurer.

On October 28, the Student Branch of the Institute of the Aeronautical Sciences at Princeton University made a field trip to Grumman Aircraft Engineering Corporation at Bethpage, L.I., N.Y. We were given interesting lectures and a plant tour. Thirty-five members and our Faculty Adviser, David C. Hazen, made the trip by chartered bus, and all agreed that it was a worth-while trip.

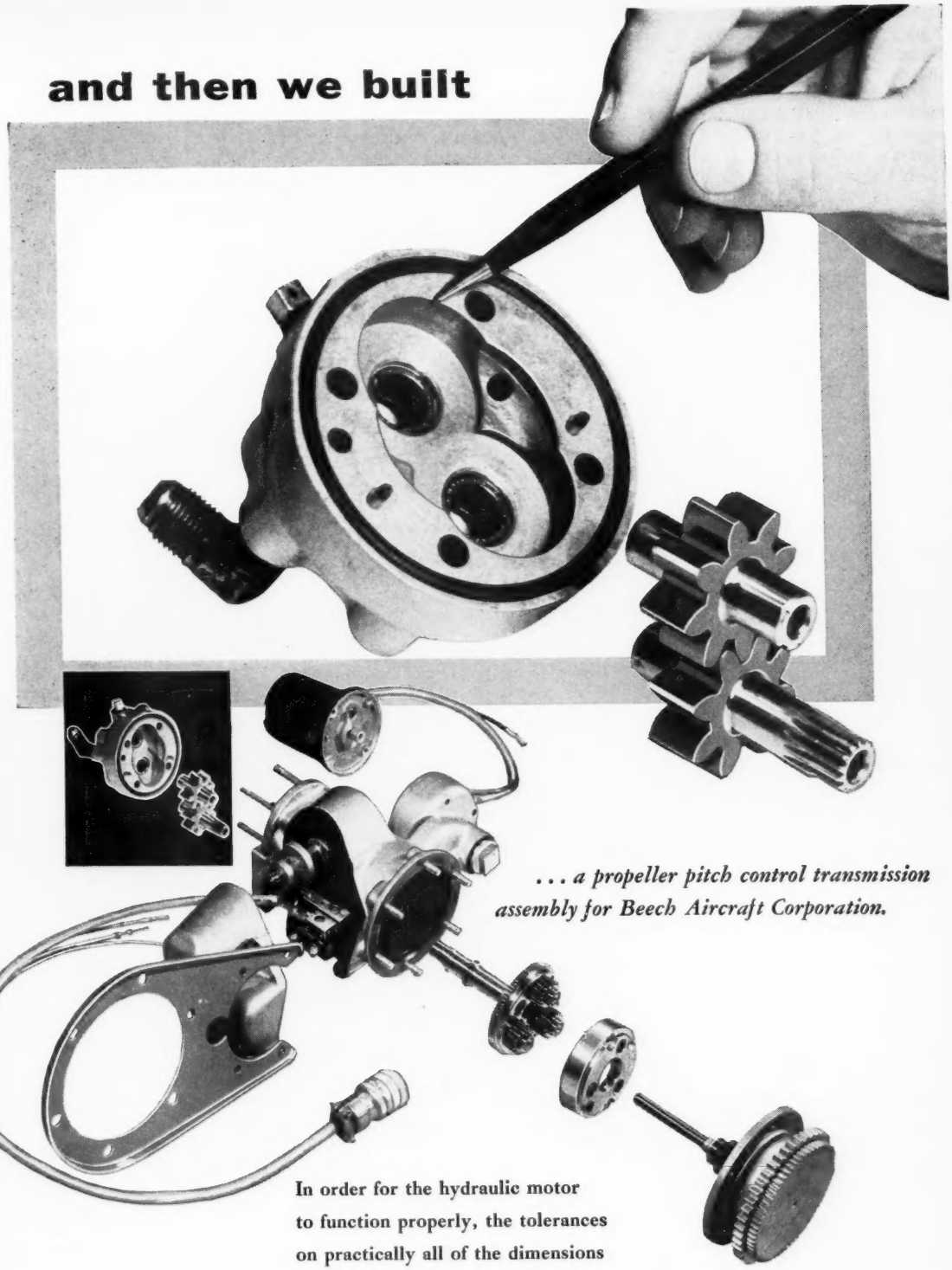
▶ On October 26, Prof. Daniel O. Dommasch, from Forrestal Research Center and a member of the faculty at Princeton University, delivered a speech on "Flight Testing." Professor Dommasch stressed the importance of obtaining flight-test data, stating that it is impossible to duplicate all the conditions encountered in actual flight by using wind tunnels and models. Professor Dommasch has had a considerable background in the field, having worked at Fairchild, Brewster, and Bell Aircraft in various capacities.

Purdue University

David Beaver
Secretary

The Branch wishes to announce the election of the following officers:

and then we built



. . . a propeller pitch control transmission assembly for Beech Aircraft Corporation.

In order for the hydraulic motor to function properly, the tolerances on practically all of the dimensions had to be held to within .0001″ or .0002″ for squareness, parallelism and concentricity.

INDIANA GEAR

INDIANA GEAR WORKS, INC. · INDIANAPOLIS, INDIANA

Robert A. Landes, Chairman; Roy Austin, Vice-Chairman; David Beaver, Secretary; and Robert Sommer, Treasurer.

A special Program Committee, headed by Chairman Ralph Billings, was appointed. John Andrews and Ernest Hartman shall serve on this committee. Ronald Lang is the Program Committee's Publicity Chairman.

Rensselaer Polytechnic Institute

Richard C. Kennedy
Secretary

The R.P.I. Student Branch held its first meeting of the new school term as an organizational session. The meeting was presided over by Robert Whitten, the newly elected Chairman. Other Branch officers were installed as follows: John Emory, Vice-Chairman; Richard Kennedy, Secretary-Treasurer; and G. Commerford, Assistant Secretary-Treasurer.

After introductory remarks by our Faculty Advisers, the films *Know Your Air Force*, *The Jet Story*, and *Airpower* were shown. The first of these showed a typical Open House at an Air Force Base. The second film, by General Electric, was about the development of the first American jet engines, later developments, and military craft that utilize jet power. The third film told the story of America's air power as a strategic military weapon.

During the refreshment period, class representatives were elected to a Branch Executive Board to facilitate greater member participation in the organization.

The enthusiasm displayed by members and faculty indicates the beginning of an entertaining and educational year.

United States Naval Academy

C. M. Charneco
Vice-Chairman

On October 9, 150 members of the Student Branch at the United States Naval Academy took part in a field trip to the Naval Air Test Center in Patuxent River, Md. The trip was informative and included a tour of the Navy's latest jet fighters, such as the F7U Cutlass, the FJ1 Fury, and the Navy's new patrol plane, the P2V. The Midshipmen were also given a demonstration by the Armament Test Division and were taken to see the Navy's new steam catapult.

▶ At the weekly meeting on October 11 the Branch had as its guest speaker Major Bolt, USMC, who is the first Marine Corps jet ace of the Korean campaign. Major Bolt gave a talk on Sabre jet tactics used against the Russian MIG'S. The Major also talked on the advantages and disadvantages of both planes, in terms of his own experience in Korea. Chairman A. G. Cicolani presided over this meeting.

United States Postgraduate School

Richard J. Peterson
Corresponding Secretary

The October meeting was highlighted with a presentation by E. H. Heinemann, Chief Engineer, Douglas Aircraft Company, Inc., El Segundo Division. He was introduced by C. G. Miller, Public Relations Manager for that Division.

Mr. Heinemann discussed the development and future of the various Navy aircraft currently being produced by his firm. He is the designer of many Navy aircraft including the famous AD "Skyraider" series and, most recently, the lightweight A4D "Skyhawk" jet attack bomber.

University of Alabama

Fred Boesche
Secretary

Joseph E. Fikes, Research Scientist, Guided Missile Division, Redstone Arsenal, was guest speaker at the September 28 meeting of our Branch. Mr. Fikes spoke briefly on the different types of work being done at Redstone Arsenal and the benefits of employment under the Civil Service System.

Plans are under way to form a glider club under the leadership of Mr. Geller, a new Instructor in the Aeronautical Engineering Department. In addition to this activity, the Branch will take part in Engineering Open House Day. The Open House Committee is planning a suitable display for the Aeronautical Engineering Department's booth at this event.

Two new officers have been elected. Ernest Manzi is now Vice-Chairman; and Fred Boesche, Secretary.

▶ Chairman Hollub opened the meeting of October 28 and gave an account of two group meetings scheduled for November. The first will be sponsored by Boeing Airplane Company and will be held on November 3. J. W. Marshall, a representative from the Seattle Division of Boeing, will give a short talk and will show movies on the new Boeing 707. The second meeting will be sponsored by the IAS Student Branch. Frank M. Johnson, Chief of Preliminary Design Section, Lockheed Aircraft Corporation, Marietta, Ga., will give a talk entitled "The Art of Compromise in Aircraft Design." The latter is scheduled for November 9 and will constitute the regular IAS meeting.

The next part of the meeting was devoted to discussing the coming "Open House." The plan to judge and award prizes, which was drawn up by Joint Engineering Council, was discussed, and the plan, as proposed, was passed. The society also decided to join with the other technical societies on campus in the establishment of a prize to be awarded each year.

Plans for an IAS Student Branch dinner were presented. The committee has chosen two possible places for the dinner and has distributed the menu and prices for each place. A speaker is being sought for the dinner, which will probably be held before Christmas.

Thomas Nylund then told of the Membership Committee's work since the last meeting. Eleven new members have come into the society, and it is hoped a potential of 61 members will be reached.

University of Cincinnati

J. Marioni, *Acting Secretary*

Howard McGlasson, of Lockheed Aircraft Corporation, spoke on recent developments at Lockheed at the October 21 meeting of this Branch. Mr. McGlasson's talk was illustrated with movies.

▶ On October 27, Dr. Paul H. Wise, Lewis Flight Propulsion Laboratory, NACA, gave a talk on the "NACA Crash Tests," illustrated by a colored movie.

University of Illinois

John Locke, *Secretary*

The University of Illinois Student Branch of the IAS held its first meeting of the fall semester on October 13. The meeting was held in Room 138 of the Electrical Engineering Building of the University of Illinois, and 86 members were present.

Chairman Phil DeProtine called the meeting to order promptly at 7:30 p.m. Minutes of the last meeting were read and approved, and a financial report was presented indicating that the Branch has $114 in capital. The Engineering Council reported that plans were being made for the Engineering Open House to be held next spring. The Branch also voted to back the St. Patrick's Day Ball, put on annually by the engineering societies of the University.

The remainder of the evening was devoted to talks given by three prominent members of the aeronautical engineering faculty of the University. The talks served as an introduction to the complete aeronautical engineering curriculum at the University of Illinois and were aimed primarily at the new students in the University. It was felt that they would appreciate learning some of the background of the field in which they have chosen to study.

BARBER COLMAN

Aircraft Controls

compact, powerful high quality d-c motors for a wide range of applications

When you specify Barber-Colman sub-fractional hp motors, you can be sure you are getting the finest of quality and dependability. Each of these motors is backed by more than 50 years of Barber-Colman Company's experience in expert designing and engineering, precision production, intensive testing. Each carries the extra quality control feature of "one responsibility," because Barber-Colman Company, as a manufacturer itself of machine and small tools, produces its own gears, plastic parts and other components. Available in both permanent magnet and split-series types . . . in various mountings and speeds, and outputs up to 1/10 hp . . . Barber-Colman d-c motors are ideally suited to power electro-mechanical actuators, gear heads, fans and blowers, and programing devices.

OTHER BARBER-COLMAN AIRCRAFT PRODUCTS

Temperature Controls
Cycling, full proportional, Micropulse, electronic . . . for military, commercial, and executive aircraft.

Valves
Wide variety of electrically and pneumatically actuated air valves for temperature and pressure control applications.

Actuators
Rotary and linear types combining gear reductions, switching, mountings, and other features to meet most applications in their load-speed class.

Positioning Controls
Integrated electric or electronic systems designed to your specifications. Anti-hunt feature provided by unique circuitry.

Thermo-Sensitive Elements
A complete line of wire and thermistor sensing elements is manufactured for use in resistance bridge type control circuits.

Ultra-Sensitive Relays
Polarized relays in sensitivities from 50 microwatts to 1 milliwatt. Wide range of coils, enclosures, mounting details.

Barber-Colman small d-c motors are available with lightweight radio noise filters to meet radio interference suppression requirements of USAF. These motors are well adapted for use as tachometer generators. Whatever your problem involving small motors, consult with Barber-Colman engineers for an expert solution. For advance technical data, write for free catalog F 4344-1.

BARBER-COLMAN COMPANY

Dept. M, 1424 Rock Street, Rockford, Illinois

Aircraft Controls • Automatic Controls • Industrial Instruments • Small Motors • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

This photograph, taken at the October 13 meeting of the University of Washington IAS Student Branch, shows *(left to right)*: Vice-Chairman J. R. Allendar; Prof. V. M. Ganzer, Honorary Chairman; R. L. (Dix) Loesch, Guest Speaker from Boeing Airplane Company; Chairman G. W. Stinnett; and Secretary-Treasurer B. D. Nelson.

Professor Stillwell, Head of the Aeronautical Engineering Department, spoke on the aerodynamics part of the aeronautical curriculum which included both applied and theoretical aerodynamics. He stressed three main objectives of the Department in this field—namely (1) to provide fundamental background for aerodynamic study in the future; (2) to introduce some applied aerodynamics, being careful not to overemphasize it; and (3) to inject various projects to stimulate interest.

He also mentioned some of the facilities here at the University of Illinois. A small slow-speed wind tunnel is used chiefly for instruction and demonstration of aerodynamic phenomena. A shock tube is available and will be used chiefly to acquaint students with the instrumentation. Another wind tunnel, located at the University of Illinois Airport, is essentially a transonic tunnel. A blowdown tunnel capable of $M = 3.0$ is also being built out there.

Dr. T. P. Torda spoke briefly on the propulsion part of the curriculum, claiming propulsion to be the most challenging field in aeronautical engineering. The importance of aerothermodynamics was stressed as the foundation for all future and more specialized studies.

Dr. H. H. Hilton, our Faculty Adviser, spoke briefly on the structural part of the curriculum. Reference was made to the importance of developing a lightweight structure into which the clean aerodynamic lines and the powerful engines could be put. A short description of the courses in the curriculum showed how this demand was being met. The chief structural problem of the day—namely, high temperature in structures due to high speeds—was noted. The need for more advanced structural thinking was also mentioned

The meeting was then adjourned, and a picture was taken of all the members present for the University's yearbook *Illio*.

University of Notre Dame

Leon E. Ring
Secretary

At the first Branch meeting, held on October 6, it was decided that the Branch will enter intramural sports. Mike Carroll is the Basketball Captain. Dave Austgen is the Bowling Captain.

A football game was scheduled for October 20 between the seniors and underclassmen.

Announcement was made by Martin Kenehan, Branch Chairman, that the NACA film on controlling crash fires would be shown on October 25.

University of Oklahoma

Carroll E. Gregg
Secretary

Herbert F. Herndon, Branch Chairman, presided over the October 19 meeting of our Branch.

Thomas L. Drennen, of McDonnell Aircraft Corporation, addressed the members, stating that the trend in aircraft design is toward high performance rather than quantity production. He also noted that "constant change" is the watchword for all aircraft manufacturers. Mr. Drennen's talk was entitled "Where Are We Going, Engineeringwise?". A film on the McDonnell Banshee was shown.

A second film, *The Speed Nut Savings Factor*, by Tinnerman Products Inc., was also shown.

University of Toronto

R. D. Cockfield
Secretary-Treasurer

A meeting of the University of Toronto Student Branch of the IAS was held on October 27 in the Debates Room of Hart House. Thirty-one members were present.

The guest speaker for the evening was Dick Hiscocks, Senior Design Engineer with The de Havilland Aircraft of Canada, Ltd. Mr. Hiscocks traced the history of bush flying in Canada, recounting some of the tales of the early pilots and aircraft. The speaker outlined the development of aircraft designed specifically for bush flying and referred to the ultimate production of the de Havilland Beaver and Otter.

A spirited question period followed in which Mr. Hiscocks was queried about de Havilland Aircraft's interests aside from the bush aircraft field. A movie entitled *Test Pilot* showed scenes of the take-offs and landings of the Beaver and Otter.

The meeting was then adjourned to the Great Hall where refreshments were served, and the discussion continued until late in the evening.

University of Washington

Bud N. Nelson
Secretary-Treasurer

Members of the IAS Student Branch at the University of Washington met on October 13 at 7:45 p.m. Seventy-five people were present. The speaker for the evening was R. L. (Dix) Loesch, Boeing Senior Experimental Test Pilot in Seattle.

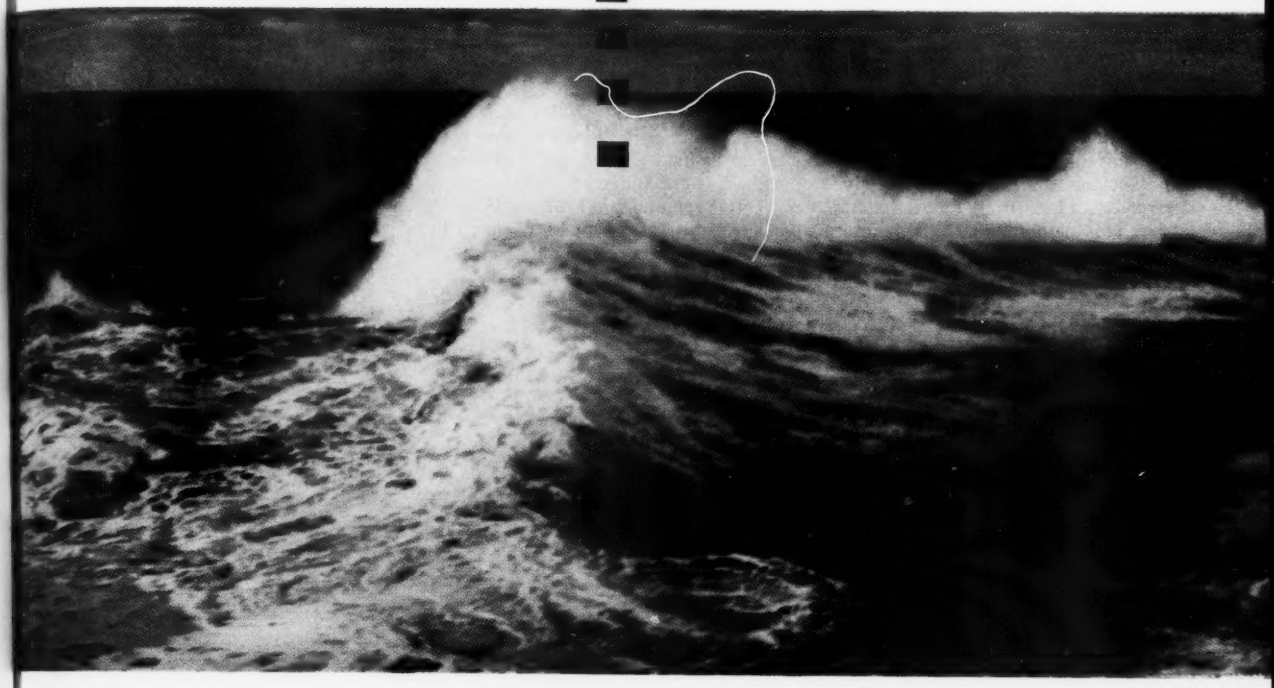
Mr. Loesch, an engineering graduate of M.I.T., has many years of flight-test experience with The Glenn L. Martin Company and the U.S. Navy. Since 1949, he has been with Boeing and has tested the Boeing Stratocruiser, C-97, B-47, B-52, and 707.

Mr. Loesch, who was introduced by Chairman Glenn W. Stinnett, spoke on "Test Flying Prototype Airplanes." The speaker classified the flight-test program under four categories: preparations, aerodynamics, structures, and systems.

The test pilot begins his preparation while the airplane is still in preliminary design. There he gets to know the general performance and is made aware of many details. The first feeling of its size comes with the prototype mock-up. In describing the mock-up, Mr. Loesch gave special attention to the advancements in cockpit arrangement made by the SAE Standard Cockpit Committee. The 707 employs the SAE Standard cockpit.

Mr. Loesch illustrated how safety at near-sonic flight could be predicted by

TOP SECRET



You see here the next great area in the rocketing progress of flight...a study in deep blue of three-fourths of our world.

To those behind the scenes, the picture says this:

Today at Martin, one of the most important airplanes in the world is about to be officially unveiled. It is the United States Navy's great new XP6M—ship No. 1 and prototype of an entirely new concept in air power, which may well launch a new era in American security and supremacy in the air.

For the rivers, lakes, and seas of the world offer countless free and indestructible bases for the swift deployment of troops, armament and materiel... "bases unlimited," within sight from the air of virtually every spot on this earth!

The Martin XP6M is a water-based aircraft, powered for unbelievable speed, and a basic design adaptable to a variety of top-priority functions.

Its name, appropriately, is The SeaMaster. Its dominion: three-fourths of our world.

MARTIN

BALTIMORE · MARYLAND

estimating the buffet limit in the C_L vs. Mach Number curve as obtained from wind-tunnel test data. He also discussed the problem of aileron reversal, which occurs with conventional controls, and how this problem has been solved on the B-52 and 707 by inboard spoilers that give a very high rate of roll.

The speaker stated that the pilot is interested in structures from two principal standpoints. The first is structural integrity and strength, which is checked in static tests and for which the airplane is highly instrumented in order to obtain stresses in flight. The second is with respect to vibration and flutter. This is checked in flight by measuring damping after a forced vibration from a tail or wing shaker.

The systems discussion was mainly concerned with the turbojet power plant and methods of obtaining an accurate indication of thrust.

Mr. Loesch closed his talk with remarks on his first flight in the 707. All students agreed that many problems described by Mr. Loesch remain to be solved by the future engineer.

University of Wichita

J. F. Cox, *Secretary*

The first meeting of the year took place on September 30 at the University's Engineering Library. Twelve Student Members and approximately 15 guests, including several faculty members, were present.

Kenneth Razak, Dean of the School of Engineering, narrated a film taken at Wichita in 1949 by Nash Motor Company. The film showed various wind-tunnel tests that were made on automobiles being marketed at that time. Dean Razak pointed out several places in the film where difficulty was encountered during the series of wind-tunnel tests. He also described briefly the 7-ft. wind tunnel in which these tests were run.

A film on the safety harness used in planes of the Beech Aircraft Corporation was then shown. The evening's program was brought to a close with a discussion of the student paper competitions to be put on next spring by the Texas and St. Louis sections.

▶ The second meeting of the year, held on October 21 in the school's Engineering Library, was the scene of the annual presentation of awards. The Scholastic Award went to Clark Beck, Class of 1954. Charles Richard Ross won the Student Paper Award.

After the showing of the film *Steel with a Thousand Qualities*, a general discussion session was held, and seven new members were inducted. Plans were made to promote this Student Branch on the Wichita campus with a view toward enlarging its membership.

Two classes of mechanical engineering students were present at this October meeting.

West Virginia University

Donald R. Peters
Corresponding Secretary

Benjamin D. Grove, Branch Chairman, addressed the October 6 meeting. Mr. Grove spoke on his summer employment with North American Aviation, Inc., at Columbus, Ohio. He discussed drawing practices and the advantages of such employment for aeronautical engineering students.

The Branch Vice-Chairman, James F. Heavner, talked about his summer work at Langley Field, NACA. His work included wind-tunnel testing and design tests and procedure.

Movies of the Dayton Air Show were shown. At a later date, the Branch attended a showing of three movies on World War II airplanes.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Cook, Frederick G. R., B.Sc. (Eng.), Chief, Aircraft Branch, British Joint Services Mission (TS), Washington, D.C.

Rice, Raymond H., B.S. Engrg., V.-P. & Chief Engr., North American Aviation, Inc.

Transferred to Associate Fellow Grade

Arnold, Lee, Ph.D. in Applied Mechanics, Prof. of Civil Engrg., Columbia Univ.; Pres., Lee Arnold Associates, Inc.

Cadambe, Venkatchalam, M.S. in Aero., Head, Div. of Applied Mechanics & Materials, National Physical Lab. of India.

Fleming, Frank N., Proj. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Jaworski, Adam, Ph.D. (Economics), Aero. Research Engr., Air Transport Board (Ottawa).

Lemmerman, Carl W., B.S.M.E., Pres., Industrial Sound Control, Inc.; Pres., Homstead Corp.; Pres., C. W. Lemmerman, Inc.; Pres., Industrial Sound Control, Ltd. (Canada).

Robbins, Norman B., S.B.Ae.E., Chief of Projects, Convair-Ft. Worth Div. of General Dynamics Corp.

Elected to MEMBER Grade

Anderson, E. N., B.S.C.E., Application Engr., Bombing Systems, Sperry Gyroscope Co. Div., The Sperry Corp.

Anderson, E. W., Ph.D., Prof. of Aero. Engrg. & Math., Iowa State College.

Becht, John J., M.S. in Ae.E., Loads & Dynamics Group Engr., Lockheed Aircraft Corp. (Marietta).

Broadston, James A., M.E., Mgr., Rocket Field Lab. (Santa Susana), North American Aviation, Inc.

Carlson, Kurt H., Sr. Design Engr., North American Aviation, Inc.

Des Lauriers, Edward J., M.A., Technical Engr., Component Devel. Sect., AGTD, General Electric Co. (Evendale).

Hassig, Hermann J., Dynamics Engr., Lockheed Aircraft Corp. (Burbank).

Hipple, William R., B.S.M.E., Capt., USAF; Asst. Chief, Technical Requirements Sect., Control Syntheses Branch, WADC, Wright-Patterson AFB.

Hoof, Robert G., Aircraft Sales Mgr., Bendix Aviation Corp. (Pacific Div.).

Horton, Peter, B.S.Ae.E., Exec. Asst. to V-P, Military Sales, Douglas Aircraft Co., Inc. (Santa Monica).

Johnson, George H., B.S.M.E., Designer "A," Boeing Airplane Co. (Seattle).

Larsen, William A., B.A., Lt. Col., USAF, Air Attaché to Japan.

MacInnes, W. F., M.S., Assoc. & Asst. Engr., Dept. of Engrg., Univ. of California at Los Angeles.

Reed, K. E., Jr., B.S.M.E., Supvr., J-47 Project, General Electric Co. (Evendale).

Schlueter, A. H., A.B. in Math., Flight Test Engr., Northrop Aircraft, Inc.

Spilger, Werner, Aero. Research Engr., Holloman Air Devel. Center.

Thompson, William F., M.B.A., Supervising Engr., Special Projects Sect., Advanced Devel. Div., AGTD, Westinghouse Electric Corp.

Transferred to MEMBER Grade

Abramson, Hyman N., M.S. Engrg. Mechanics, Assoc. Prof. of Aero. Engrg., The A&M College of Texas; Assoc. Research Engr., The Texas Engineering Experiment Station.

Arthur, H. Neil, B. of Ae.E., Field Engr., Wright Aero. Div., Curtiss-Wright Corp.

Bennett, Willard B., B.S.Ae.E., Design Engr., Thermodynamics Design Group, Convair-Ft. Worth Div. of General Dynamics Corp.

Bernstein, Stanley, B.Ae.E., Deputy Chief of Guided Missile Projects, Ordnance Missile Labs., Redstone Arsenal.

Beverage, Allan D., B.S.M.E., Application & Installation Planning Engr., AGTD, General Electric Co.

Brenner, Claude W., S.M.Ae.E., Sr. Engr., Allied Research Associates, Inc.

Clemen, Arthur T., M.S. in Ae.E., Sr. Structures Engr., Convair-Ft. Worth Div. of General Dynamics Corp.

Covey, Robert E., M.Sc. in Ae.E., Operations Engr., Jet Propulsion Lab., California Institute of Technology.

RELIABLE PRESSURIZATION

for aircraft equipment

The custom job of supplying pressurization units for airborne electronic equipment is Eastern's specialty. Meeting all appropriate government specifications, units can be furnished within the limits shown at right. Dehydrators available. We invite inquiries and specific requests concerning your specifications.

General Requirements:

Altitude: 0-70,000 ft.
Delivery: 0-3600 cu.in./min. free delivery
Discharge Pressure: 0-60 p.s.i.
Temperature: —65°F to +160°F
Voltages: any standard voltage.

New Aviation Products Catalog covering Electronic Tube Cooling Units, Hydraulic Equipment, and Pressurization Units sent on request.

Eastern

INDUSTRIES, INC.
100 SKIFF STREET
HAMDEN 14, CONN.

Des Jardins, Paul R., B.S. in Ae.E., Flight Test Engr., North American Aviation, Inc. (Downey).

Dryer, Murray, M.S. in M.E. (Aero.), Aero. Research Scientist, Aerodynamics, Lewis Flight Propulsion Lab., NACA (Cleveland).

Gore, Lawrence L., B.S. in Ae.E., Structures Engr. "A," Stress Unit, Boeing Airplane Co. (Wichita).

Heilenday, Frank W., M.S.Ae.E., Sr. Dynamics Engr., Convair-San Diego Div. of General Dynamics Corp.

Kresse, Arthur O., B.A.E., Design Engr., R&D, Thompson Products, Inc.

Lowe, Warner S., M. of Ae.E., Flight Test Engr. "A," Ryan Aeronautical Co.

Marlin, Donald L., B.S.Ae.E., Stress Analyst, Ryan Aeronautical Co.

Overmyer, Ellis J., M.S.M.E., Assoc. Research Engr., Boeing Airplane Co. (Seattle).

Papanek, Andrew P., M.S.Aero.E., Mgr., Special Projects Sect., Jack & Heintz, Inc.

Payzer, Robert J., B.M.E., Technical Engr., General Electric Co. (Evendale).

Probstein, Ronald F., Ph.D. Ae.E., Asst. Prof. of Engrg. & Applied Math., Brown Univ.

Ramsey, Joseph C., B.S.Ae.E., Aerodynamics Engr., Convair-San Diego Div. of General Dynamics Corp.

Rhees, Thomas R., M.Sc. in Ae.E., Lt. Comdr., USN; Maintenance Workload Officer, Staff, Comdr. Air Force, Pacific Fleet.

Rhodes, Nordae L., B.Sc.Ae.E., Sr. Engr., The Glenn L. Martin Co.

Schaufele, Roger D., M.S. in Aero., Lt. (j.g.), AEDO, BuAer, Dept. of the Navy (Washington, D.C.).

Schumann, William A., B.S.M.E., Flight Test Engr., Allison Div., General Motors Corp.

Stewart, Walter C., Jr., M.Sc. in Engrg., Major, USMC; Member, Marine Jet Fighter Squadron, USMC.

Elected to Associate Member Grade

Bennett, Martin, M.A., Technical Writer, Sperry Gyroscope Co. Div., The Sperry Corp.

Dodge, Eric D., B.A., Transportation Analyst, Knappen-Tippetts-Abbett-McCarthy.

Elliott, Roy W., B.S. in C.E., Supvr., Technical Film Cataloging Project, ARDC Contract, IAS (San Diego).

Evans, Howard Kirk, A.A. in Ae.E., Proj. Sales Engr., System Coordination, AiResearch Mfg. Div., Garrett Corp.

Murphy, Joseph S., Engrg. Editor, American Aviation Publications.

Rainey, Ronald E., Building Mgr., IAS (Los Angeles).

Schilling, Lewis R., B.S.I.E., Pres., Kolcast Industries, Inc.

Warren, Henry W., Supvr., Field Training Dept., Aeronautical School, Sperry Gyroscope Co. Div., The Sperry Corp.

Zesiger, Denton E., B.A., Mgr., Subcontracts Projects, Goodyear Aircraft Corp.

Elected to Technical Member Grade

Dougan, Roger R., B.S., Engr., Air Arm Div., Westinghouse Electric Corp.

Kuehnegger, Walter, Ing., Design Engr., Fleet Mfg., Ltd. (Ontario).

Sokolsky, Saul, B.M.E., Intermediate Test Engr., Wright Aero. Div., Curtiss-Wright Corp.

Velez, Oscar G., A & M.E., Mech. Engr., Experimental & Devel. Sect., Ford Motor Co.

Transferred to Technical Member Grade

Aasen, Leiv B., Artium Degree, Design & Maintenance Engr., Norsk Flyindustri A/S (Norway).

Allen, Robert V., B.S. in Ae.E., Jr. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Anderson, David E., B.S. in Ae.E., 2nd Lt., USAF.

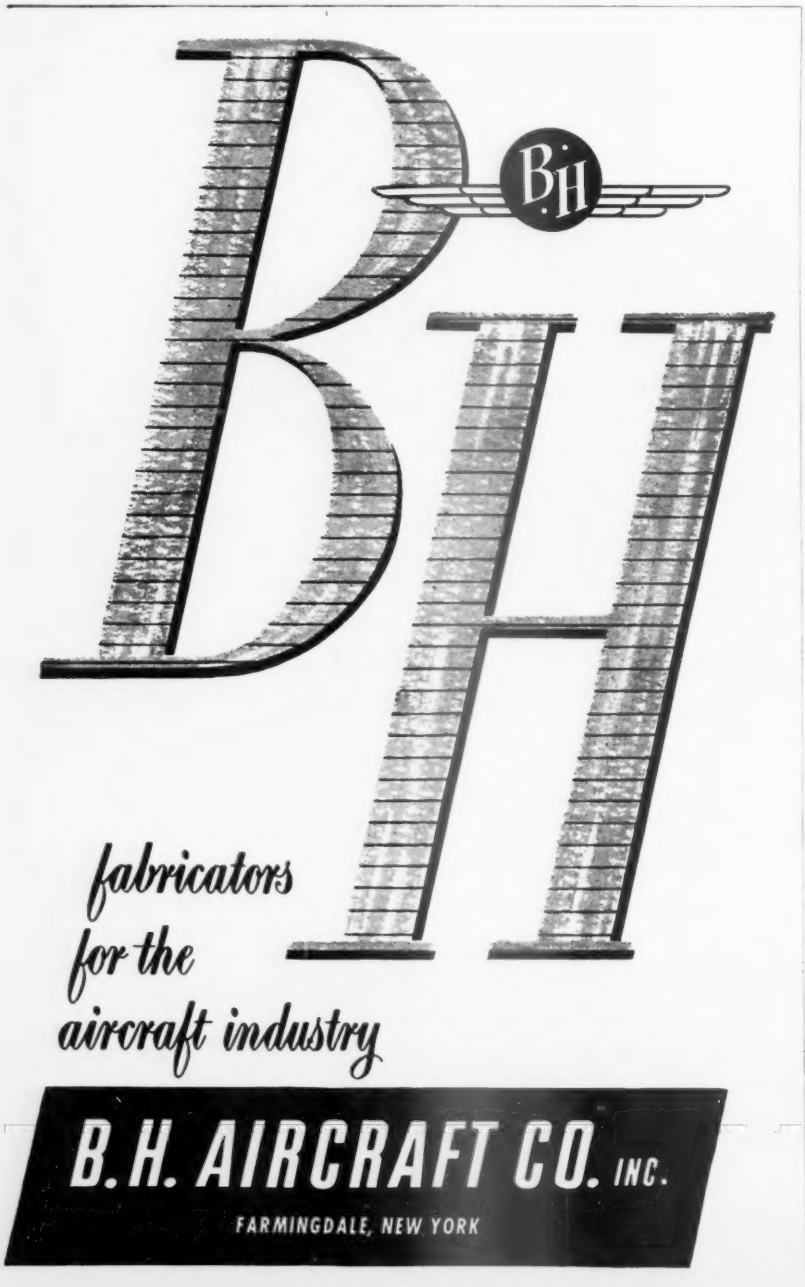
Barnard, James D., B.S. in Ae.E.

Bennett, Floyd V., B.S. in Ae.E., Aero. Research Intern, NACA, Langley AFB.

Bergman, John F., B.S., Lt., USAF, Holloman AFB.

Bitonti, Frank Edward, B.S. in Ae.E., 2nd Lt., USAF.

Boyd, Berkeley S., Capt., USAF; Proj. Engr., Wright-Patterson AFB.



Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

Abbreviations for Titles of Periodicals and Reports **96**

Aerodynamics 104
Boundary Layer & Thermoaerodynamics 104
Control Surfaces 104
Fluid Mechanics & Aerodynamic Theory 104
Internal Flow 105
Stability & Control 105
Wings & Airfoils 106
Aeroelasticity 106
Aeronautics, General 106
Airplane Design 106
Air Conditioning & Pressurization 106
Cockpits 106
Landing Gear 106
Wing Group 108
Airports
Helicopter Stations 108
Traffic Control 108
Aviation Medicine 108
Computers 108
Education & Training 108
Electronics
Antennas 108
Circuits & Components 108
Communications 108
Construction Techniques 108
Delay Lines 108
Dielectrics 108
Electronic Tubes 108
Magnetic Devices 110
Measurements & Testing 110
Navigation Aids 110
Networks 111
Noise & Interference 111
Radar 111
Semiconductors 111
Telemetry 111
Transmission Lines 111
Equipment 111
Electric 111
Hydraulic & Pneumatic 111
Flight Operating Problems
Cruise Control & Piloting 111
Fuels & Lubricants 111
Gliders 112
Ice Formation & Prevention 112
Instruments
Automatic Control 112
Flight Instruments 112
Flow Measuring Devices 112
Pressure Measuring Devices 112
Stress & Strain Measuring Devices 112
Machine Elements
Bearings 112
Gears & Cams 112
Mechanisms & Linkages 112
Rotating Discs & Shafts 112
Materials 112
Ceramics & Ceramals 112
Corrosion & Protective Coatings 112
Metals & Alloys 113
Metals & Alloys, Nonferrous 113
Nonmetallic Materials 113
Testing 113
Mathematics 114
Meteorology 114
Military Aviation & Armament 114
Missiles 114
Noise Reduction 114
Photography 114
Power Plants
Jet & Turbine 114
Reciprocating 116
Production
Metalworking 116
Welding 116
Reference Works 116
Rotating Wing Aircraft 116
Safety 116
Structures 116
Bars & Rods 116
Beams & Columns 116
Connections 117
Cylinders & Shells 117
Elasticity & Plasticity 117
Plates 117
Weight Analysis & Control 118
Wings 118
Thermodynamics
Combustion 118
Heat Transfer 118
Water-Borne Aircraft 118
Wind Tunnels & Research Facilities 118

II. BOOKS REVIEWED IN THIS ISSUE

Some Basic Problems of the Mathematical Theory of Elasticity. N. I. Muskhelishvili 121

Reviewed by Harry Zuckerberg, Professional Engineer

Book Notes **122**

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS. Reference citations in the Aeronautical Reviews Section give the total number of pages for report and booklet materials; only the beginning page is given for periodical articles.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $15 to $20 per 1,000 words, depending on the language.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

Abbreviations for Titles of Periodicals and Reports

Titles of periodicals and reports cited in the Aeronautical Reviews Section are abbreviated in order to conserve space and to expedite the flow of materials. Selection of titles in this list of abbreviations is based on materials received during the past year. Reference citations are listed in the briefest form, with only the first page given for periodicals and the total number of pages for reports and other types of publications.

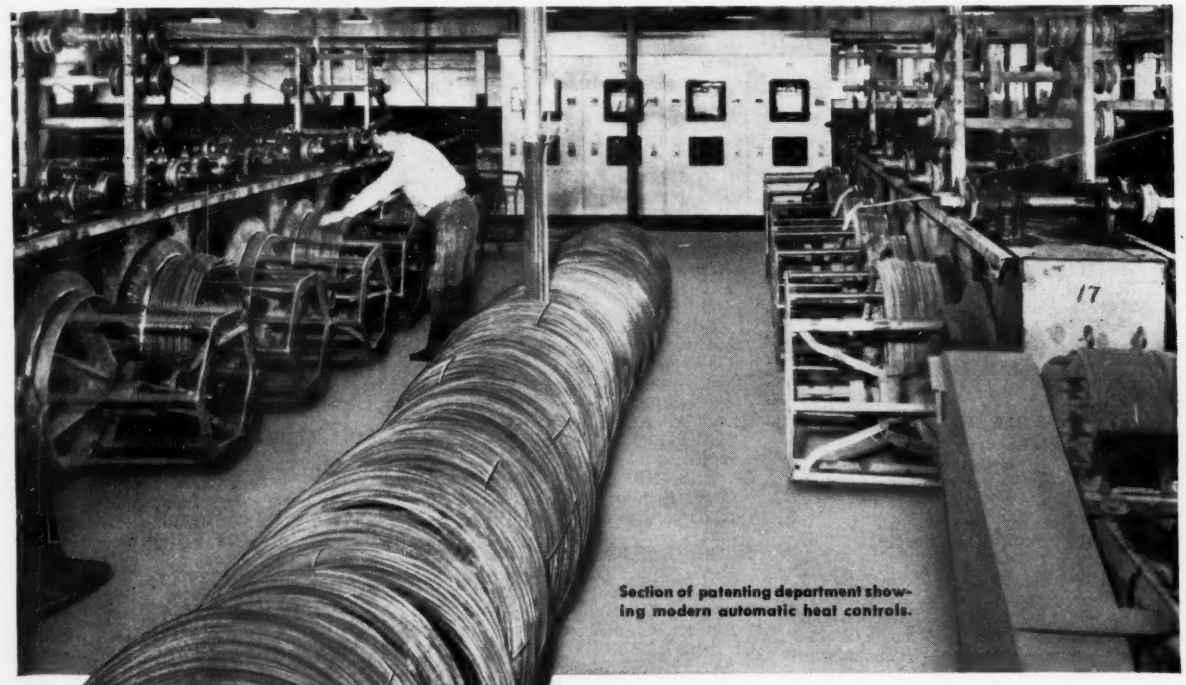
Publications reviewed are filed permanently in the IAS Library. Requests for loans of materials should be directed to the Librarian, IAS Library, 2 E. 64 St., New York 21, N.Y.

A&M Coll. Tex. Eng. Exp. Sta. Res. Rep. Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Research Report
Acta Polytechnica (Stockholm)
Aero Dig. Aero Digest
Aero. Argentine Commun. & Inform. Aeronautica Argentine, Communicación e Información
Aero. Eng. Rev. Aeronautical Engineering Review
Aero. Quart. The Aeronautical Quarterly
Aero. Res. TN; Bul. Aero Research Technical Notes; Bulletin
Aerodynamisches Inst. Tech. Hochschule, Braunschweig, Bericht. Aerodynamisches Institut der Technischen Hochschule, Braunschweig, Bericht
Aeronautics
The Aeroplane
L'Aerotecnica (Rome)
Aerovox Res. Worker. Aerovox Research Worker
AHS Papers. American Helicopter Society, Papers
AIAA Papers. Aircraft Industries Association of America, Papers
AIEE Papers. American Institute of Electrical Engineers, Papers
Air Facts
Air Force
Air Line Pilot
Air Pictorial
Air Rev. Air Revue (Brussels)
Air Transp. Air Transportation
Air U Quart. Rev. Air University Quarterly Review
Airborne Inst. Lab. Proj. Rep. Airborne Instruments Laboratory, Project Report
Aircraft (Australia)
Aircraft (Canada)
Aircraft Eng. Aircraft Engineering
Aircraft Heating Dig. Aircraft Heating Digest
Aircraft Prod. Aircraft Production
Airport Operators Council, Papers
Airports & Air Transp. Airports & Air Transportation
Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review
ALPA Papers. Air Line Pilots Association, Papers
Aluminium Devel. Assn. Res. Rep. Aluminium Development Association, Research Reports (London)
Am. Av. American Aviation
Am. Helicopter. American Helicopter
Am. J. of Phys. American Journal of Physics
An. d. Phys. Annalen der Physik (Germany)
An. Fis. Quim. Anales de Fisica y Quimica (Madrid)
An. Soc. Cientifica. Anales Sociedad Cientifica (Argentina)
Anal. Chem. Analytical Chemistry
Antiaircraft J. Antiaircraft Journal
Appl. Hydraulics. Applied Hydraulics
Appl. Mech. Rev. Applied Mechanics Reviews
Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A (Mechanics, Heat, Chemical Engineering, Mathematical Methods)
Appl. Sci. Res., Sect B. Applied Scientific Research, Section B (Electrophysics, Acoustics, Optics, Mathematical Methods)
Arch. für Tech. Messen (Munich)
Arch. Mech. Stosowanej (Warsaw). Archiwum Mechaniki Stosowanej, Zaklad Mechaniki Ośrodków Ciagłych Polskiej Akademii Nauk (Warsaw, Poland)
Argonne Natl. Lab. Rep. Argonne National Laboratory, Reports
ASCE Air Transp. Div. Papers; Preprints. American Society of Civil Engineers, Air Transport Division, Papers; Preprints
ASME Preprints; Papers. American Society of Mechanical Engineers, Preprints; Papers
ASTM Bul. American Society for Testing Materials, Bulletin
ATA Papers. Air Transport Association (of America), Papers
Audio
Australia, Aero. Res. Consultative Comm. Rep. Australia, Department of Supply, Aeronautical Research Consultative Committee, Reports
Australia, ARL EN; IN; Rep.; S&M Monogr.; S&M TM; Notes. Australia, Department of Supply, Aeronautical Research Laboratories, Engines Note; Instruments Note; Reports; Structures and Materials Monographs; Structures and Materials Technical Memorandum; other Notes
Australia, CSID Aero. Res. Rep. Australia, Council for Scientific and Industrial Research, Aeronautical Research Report
Australian J. of Appl. Sci. Australian Journal of Applied Science
Australian J. Phys. Australian Journal of Physics [formerly Australian Journal of Scientific Research, Series A (Physical Sciences)]
Auto. Ind. Automotive Industries
Auto-Technik (Berlin)
Av. Age. Aviation Age
Av. Week. Aviation Week
Aviaçao (Rio de Janeiro)

Bearing Engr. Bearing Engineer
Bee Hive
Bell Aircraft Rep. Bell Aircraft Corporation, Reports
Bell System Tech. J. Bell System Technical Journal
Bendix Av. Eng. Rep. Bendix Aviation Corporation, Engineering Reports
Boeing Mag. Boeing Magazine
Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin
Brit. J. Appl. Phys. British Journal of Applied Physics
Brit. Welding J. British Welding Journal
Brown-Boveri Rev. Brown-Boveri Review
Bul. AMS. Bulletin of the American Meteorological Society
Bus. Flying. Business Flying

CAI Log. Canadian Aeronautical Institute, Log
Can. Airline Pilot. Canadian Airline Pilot
Can. Av. Canadian Aviation
Can. J. Phys. Canadian Journal of Physics
Can. J. Tech. Canadian Journal of Technology
Canada, NAE HSAL Rep. Canada, National Aeronautical Establishment, High Speed Aerodynamics Laboratory, Reports
Canada, NAE LR; Note; Quart. Bul.; Rep. Canada, National Aeronautical Establishment, Laboratory Report; Note; Quarterly Bulletin; Reports
Canada, NRC Div. Mech. Eng. Rep. Canada, National Research Council, Division of Mechanical Engineering, Reports
Canada, RCAF, Rockcliffe, Rep. Canada, Royal Canadian Air Force, Rockcliffe, Reports
CEC Recordings
Chartered Mech. Engr. The Chartered Mechanical Engineer (London)
Chrysler Eng. Div. Rep. Chrysler Corporation, Engineering Division, Reports
Ciampino (Interairport) (Rome)
CIT Jet Propulsion Lab. Prog. Rep. California Institute of Technology, Jet Propulsion Laboratory, Progress Reports
CIT Mech. Eng. Lab. Rep. California Institute of Technology, Mechanical Engineering Laboratory, Reports
CIT Papers. California Institute of Technology, Papers
Coll. of Aeronautics, Cranfield, Rep. College of Aeronautics, Cranfield, England, Reports
Collins Signal
Commun. on Pure & Appl. Math. Communications on Pure and Applied Mathematics
Cook Res. Labs. Papers. Cook Research Laboratories, Papers
Cornell Aero. Lab. FRM; Rep.; Transl. Cornell Aeronautical Laboratory, Inc., Flight Research Memorandum; Reports; Translations
Cornell U. Med. Coll. Crash Injury Res. Papers. Cornell University Medical College, Crash Injury Research Papers
Corrosion
Curtiss-Wright Corp., Wright Aero. Div., Rep. Curtiss-Wright Corporation, Wright Aeronautical Division, Reports

de Havilland Gazette
Dickinson Law Rev. Dickinson Law Review
Douglas Rep. Douglas Aircraft Company, Inc., Reports
Douglas Serv. Douglas Service



Section of patenting department showing modern automatic heat controls.

wire control *to save you money!*

• The accuracy with which your wire specifications are met, *and held,* quite naturally has an important bearing on the cost, speed and quality of your production. That's why you can profit by National-Standard's facilities and exceptional experience in producing fine wire of many metals and alloys for exacting needs.

Here, all phases of wire processing . . . drawing, cleaning, heat treating, plating, finishing . . . are controlled to a degree and accuracy never exceeded, not often equalled. It's a firmly rooted National-Standard policy that can save you time and money.

Remember, too, another National-Standard policy that can work to your advantage—highly qualified engineering service in the development and application of special wire to solve special problems. As always, it's yours for the asking.

NS NATIONAL-STANDARD Company NILES, MICHIGAN

DIVISIONS OF NATIONAL-STANDARD CO.

ATHENIA STEEL.. *Clifton, N. J.*	Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD.. *Niles, Mich.*	Tire Wire, Stainless, Fabricated Braids and Tape
REYNOLDS WIRE.. *Dixon, Illinois*	Industrial Wire Cloth
WAGNER LITHO MACHINERY.. *Jersey City, N. J.*	Metal Decorating Equipment
WORCESTER WIRE WORKS.. *Worcester, Mass.*	Round and Shaped Steel Wire, Small Sizes

Elec. Commun. Electrical Communication
Elec. Eng. Electrical Engineering
Elec. Mfg. Electrical Manufacturing
Electronic Eng. Electronic Engineering
Electronics
Electronics Forum. See: Proc. Inst. Electronics
Eng. J. Engineering Journal
The Engr. The Engineer
Engr. Dig. Engineer's Digest
Escher Wyss News
Esso Air World
Esso Standard Oil Co. Rep. Esso Standard Oil Company, Reports
ETH Inst. für Aerodynamik (Zurich), Mitteilungen. Eidgenössische Technische Hochschule, Institut für Aerodynamik (Zurich), Mitteilungen

Fasteners
Flight
Flight Control (Bendix)
Flight Mag. Flight Magazine
Flight Safety Foundation Mech. Bul. Flight Safety Foundation, Inc., Mechanics Bulletin
Flight Safety Foundation, Papers
Flying
Flying Safety (USAF). Flying Safety (United States Air Force)
Focke-Wulf Flugzeugbau, Gesellschaft mit beschrankter Haftung, Bremen/Werkstoff-Versuchsabteilung, Technische Berichte
Foote Prints
France, Min. de l'Air BST; NT; PST. France, Ministère de l'Air, Bulletin des Services Techniques; Notes Techniques; Publications Scientifiques et Techniques
France, ONERA Pubs. France, Office National d'Études et de Recherches Aéronautiques, Publications
Franklin Inst. Labs. TR. Franklin Institute Laboratories for Research and Development, Technical Reports
French Acad. Devel. Aero. Res. & Aero. Tech. Serv. Rep. French Academy for the Development of Aeronautical Research and Aeronautical Technical Service, Reports
French Comm. Devel. Aero. Res. TN. French Committee for the Development of Aeronautical Research, Technical Notes
The Frontier
Fulmer Res. Inst. Rep. Fulmer Research Institute Limited, Reports

GALCIT Memo. Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, Calif., Memorandums
Garbell Res. Foundation, Aero. Ser. Garbell Research Foundation, Aeronautical Series
G-E Rev. General Electric Review
Gen. Radio Exp. General Radio Experimenter
Ges. d. Wiss. Göttingen, Nach, a. d. Math. Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse, Nachrichten aus der Mathematik (Germany)
GFW Forschungsreihe, Bericht. Gesellschaft für Weltraumforschung, Forschungsreihe, Bericht (Stuttgart, Germany)
GM Eng. J. General Motors Engineering Journal
Goodyear Aircraft Corp. Rep. Goodyear Aircraft Corporation, Reports
Gt. Brit., AAEE Rep. Great Britain, Aeroplane and Armament Experimental Establishment, Boscombe Down, Reports
Gt. Brit., AERE Rep. Great Britain, Atomic Energy Research Establishment, Reports
Gt. Brit., ARC CP. Great Britain, Aeronautical Research Council, Current Papers
Gt. Brit., ARC R&M. Great Britain, Aeronautical Research Council, Reports & Memoranda
Gt. Brit., DSIR FPR Bul. Great Britain, Department of Scientific & Industrial Research, Forest Products Research Bulletin
Gt. Brit., Meteorological Off. Prof. Notes & Reps. Great Britain, Meteorological Office, Professional Notes and Reports
Gt. Brit., MOS DGC TIB Rep. & Transl. Great Britain, Ministry of Supply, Government Defense Council, Technical Information Bureau, Reports and Translations
Gt. Brit., NGTE Rep. Great Britain, National Gas Turbine Establishment, Reports
Gt. Brit., NPL Aerodynamics Div. Rep. Great Britain, National Physical Laboratory, Aerodynamics Division, Reports
Gt. Brit., RAE FPRC Rep. Great Britain, Royal Aircraft Establishment, Flying Personnel Research Committee, Reports
Gt. Brit., RAE Rep. Great Britain, Royal Aircraft Establishment, Reports
Gt. Brit., RAE TN. Great Britain, Royal Aircraft Establishment, Technical Notes
Grumman Aircraft Eng. Corp. Res. Dept. Rep. Grumman Aircraft Engineering Corporation, Research Department, Reports

Handley-Page Bul. Handley-Page Bulletin
Harvard U. Cruft Lab. TR. Harvard University, Cruft Laboratory, Technical Reports
Hawker Siddeley Rev. Hawker Siddeley Review
Hewlett-Packard J. Hewlett-Packard Journal
La Houille Blanche (France)
Hunting Group Rev. Hunting Group Review
Hydraulic Engr. Hydraulic Engineer

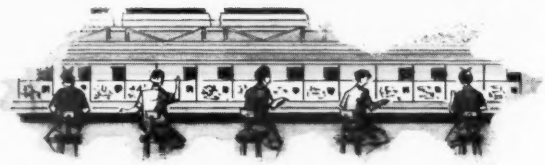
IAS Preprints; Papers. Institute of the Aeronautical Sciences, Preprints; Papers
IATA Bul. International Air Transport Association Bulletin
ICAO Bul. International Civil Aviation Organization Bulletin
IME Auto. Div. Proc. Institution of Mechanical Engineers, Automobile Division, Proceedings
IME Proc. (A). Institution of Mechanical Engineers, Proceedings (A)
IME Proc. (B), Appl. Mech.; Hydraulics. Institution of Mechanical Engineers, Proceedings (B), Applied Mechanics; Hydraulics
INCO. (International Nickel Company, Inc.)
Ind. & Eng. Chem. Industrial and Engineering Chemistry
Ind.-Anzeiger. Industrie-Anzeiger (Essen, Germany)
Ind. Labs. Industrial Laboratories
Ind. Quality Control. Industrial Quality Control
Ind. Sci. & Eng. Industrial Science and Engineering (Advanced-student edition of *Industrial Laboratories*)
Indian AF Quart. Indian Air Force Quarterly
Indian Airman
Indian Skyways
Ingen.-Arch. Ingenieur-Archiv (Germany)
L'Ingegnere (Italy)
Inst. Français du Transport Aérien, Res. Papers. Institut Français du Transport Aérien, Research Papers
Inst. für Praktische Mathematik Tech. Hochschule. Institut für Praktische Mathematik Technische Hochschule (Darmstadt, Germany)
Instrumentation
Instruments & Automation
Interavia (Monthly)
Interchem. Rev. Interchemical Review
Internatl. Nickel Devel. & Res. Div. Tech. Bul. International Nickel Company, Development & Research Division, Technical Bulletins
Iowa Eng. Exp. Sta. Eng. Rep. Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, Engineering Report
Ireland, Meteorological Serv., Geophys. Pubs. Ireland, Meteorological Service, Geophysical Publications
ISA J. Instrument Society of America Journal. In: **Instruments**
Istanbul Tech. U. Bul. Istanbul Technical University, Bulletin

J. Acoustical Soc. Am. Journal of the Acoustical Society of America
J. ACS. Journal of the American Chemical Society
J. Aero. Sci. Journal of the Aeronautical Sciences
J. Aero. Soc. India. Journal of The Aeronautical Society of India
J. Air Law & Commerce. Journal of Air Law & Commerce
J. Appl. Mech. Journal of Applied Mechanics
J. Appl. Phys. Journal of Applied Physics
J. ARS. Journal of the American Rocket Society. See **Jet Propulsion**
J. ASNE. Journal of the American Society of Naval Engineers
J. Atmos. & Terrestrial Phys. Journal of Atmospheric & Terrestrial Physics
J. Av. Med. Journal of Aviation Medicine
J. Brit. Interplanetary Soc. Journal of the British Interplanetary Society
J. Electrodepositors' Tech. Soc. Journal of the Electrodepositors' Technical Society
J. Eng. Educ. Journal of Engineering Education
J. Franklin Inst. Journal of the Franklin Institute
J. GAPAN. Journal of the Guild of Air Pilots and Air Navigators
J. Helicopter Assn. Gt. Brit. Journal of the Helicopter Association of Great Britain
J. Hokkaidô Gakugei U., Sect. B. Journal of Hokkaidô Gakugei University, Section B (Japan)
J. Indian Inst. Sci. Journal of the Indian Institute of Science
J. Inst. Metals. Journal of the Institute of Metals
J. Inst. Navigation. Journal of the Institute of Navigation
J. Inst. Transp. Journal of the Institute of Transport
J. Japan Soc. Appl. Mech. Journal of the Japan Society for Applied Mechanics
J. London Math. Soc. Journal of the London Mathematical Society
J. Math. & Phys. Journal of Mathematics and Physics
J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids
J. Meteorology. Journal of Meteorology
J. RAeS. Journal of the Royal Aeronautical Society

Research

Development

Design



Production

AN INTEGRATED ELECTRONICS OPERATION

Navigational Gear
Guided Missiles
Radar
Noise Rejection
Counter Measures
Computers
Communications
Terminal Equipment
Transistors

Hoffman
LABORATORIES, INC.
A SUBSIDIARY OF HOFFMAN RADIO CORP.

Hoffman's reputation for getting things done is due, in part, to the unification of Research-Development-Design-Production into one closely integrated electronics operation. At Hoffman – instead of the usual four completely separate operations – one technical director is assigned to co-ordinate each new project from start to finish. Every new project is developed in close cooperation with the divisions ahead, including the practical problems of quantity production. This integration practically eliminates the all-too-common duplications and overlapping of functions, the errors and re-work caused by poor liaison, and materially cuts down the usual time lag between the testing of the prototype and actual production. Hoffman has become a leader in electronics by doing progressively complex jobs – to specifications – to cost estimates – and on schedule.

Write for your copy of a
REPORT FROM HOFFMAN LABORATORIES

HOFFMAN LABORATORIES, INC.
A Subsidiary of Hoffman Radio Corp.
3761 South Hill Street, Los Angeles 7, California

Challenging opportunities for outstanding electronics and mechanical engineers. Write Director of Engineering.

J. Sci. & Ind. Res. Journal of Scientific and Industrial Research
J. Sci. Instr. Journal of Scientific Instruments
J. Sci. Res. Journal for Scientific Research
J. SCMA. Journal of the Southern California Meter Association. In: **Instruments**
J. SLAE. Journal of the Society of Licensed Aircraft Engineers (incorporating The Technical Instructor)
J. Southern Res. Journal of Southern Research
J. Space Flight. Journal of Space Flight
Japan, NCB Rep. Japan, Numerical Computation Bureau, Reports
Japan Sci. Rev. Japan Science Review (Engineering Sciences)
Jet Age
Jet Propulsion. (Formerly, **J. ARS**)

Konstruktion (Germany)
Konstruktionbucher (Berlin)
Kunststoffe (Munich)
Kyushu U., Japan, Rep. Res. Inst. Appl., Mech. Kyushu University, Japan, Reports of Research Institute for Applied Mechanics

La. State U. Eng. Exp. Sta. Bul. Louisiana State University, Engineering Experiment Station, Bulletin
Lenkurt Demodulator
Lockheed Aircraft Rep. Lockheed Aircraft Corporation, Reports
Lockheed Field Serv. Dig. Lockheed Field Service Digest
The Log
Lubrication
Lubrication Eng. Lubrication Engineering

Mach. Des. Machine Design
Mag. of Magnesium. Magazine of Magnesium
Mag. of Standards. The Magazine of Standards
Magyar Kémiai Folyóirat (Budapest)
Marconi Rev. Marconi Review
Martin Star
Materials & Methods
Mech. Eng. Mechanical Engineering
Mech. Engr. (India). Mechanical Engineer, Bangalore, India (Journal of the Mechanical Engineering Society, Indian Institute of Science)
Metal Treatment
Metall (Berlin)
Metalloberfläche (Munich)
Metallurgia
Metallurgia Italiana (Milan)
Meteorological Mag. The Meteorological Magazine
Mil. Surgeon. Military Surgeon
Miss. State U. Eng. Res. Sta. Res. Rep. Mississippi State University, Engineering Research Station, Research Reports
Mitteil. Hydraulischen Inst. Tech. Hochschule, München. Mitteilungen des Hydraulischen Instituts der Technischen Hochschule, München
Mitteil. Max-Planck-Inst. für Strömungsforschung. Mitteilungen aus dem Max-Planck-Institut für Strömungsforschung (Göttingen)
Modern Metals
Motorola Newsgram

N.C. State Coll. Eng. Sch. Bul. North Carolina State College, Engineering School Bulletin
Natl. Acad. Sci. NRC Rep. National Academy of Sciencies of the United States, National Research Council, Reports
Natl. Assn. State Av. Off. Papers. National Association of State Aviation Officials, Papers
NATO AGARD Memo. North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Memorandum
Naturwissenschaften (Germany)
Naval Av. News. Naval Aviation News
Navigation
Netherlands, Koninklijke Nederlandse Akademie van Wetenschappen, Proc. (Proceedings)
Netherlands, Mathematisch Centrum, Amsterdam, Rep. (Reports)
Netherlands, NLL Rep. (Rep. & Trans.) Netherlands, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), Amsterdam, Reports (Reports and Transactions)
New Frontiers
New Zealand Flying
NFPA Bul.; Papers; Rep. National Fire Protection Association, Bulletins; Papers; Reports
NFPA Comm. Av. & Airport Fire Protection Bul.; Rep. National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletins; Reports
North Amer. Av. Spec. Res. Rep. North American Aviation Corporation, Special Research Reports
NYU Res. Rev. New York University, College of Engineering, Research Review

O. State U. Eng. Exp. Sta. News. The Ohio State University, Engineering Experiment Station, News
Ordnance
Ore. State Coll. Eng. Exp. Sta. Bul. Oregon State College, Engineering Experiment Station, Bulletin
Organic Finishing
The Oscillographer

Pacific J. Math. Pacific Journal of Mathematics
Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics
Pegasus
Philips Tech. Rev. Philips Technical Review
Philos. Mag. Philosophical Magazine
Philos. Trans. Royal Soc. (London), Ser. A. Philosophical Transactions of the Royal Society of London, Series A, Mathematical and Physical Sciences
Photogrammetria
Photogrammetric Eng. Photogrammetric Engineering
Photographic Eng. Photographic Engineering
Power Jets Memo. Power Jets (Research and Development) Limited, Memorandum
Princeton U. Dept. Aero. Eng. Rep. Princeton University, Department of Aeronautical Engineering, Reports
Proc. Cambridge Philos. Soc. Proceedings, Cambridge Philosophical Society
Proc. IEE, Part I. Proceedings of the Institution of Electrical Engineers, Part I (General)
Proc. IEE, Part II. Proceedings of the Institution of Electrical Engineers, Part II (Power Engineering)
Proc. IEE, Part III. Proceedings of the Institution of Electrical Engineers, Part III (Radio and Communication Engineering)
Proc. Inst. Electronics. Proceedings of the Institution of Electronics (Electronics Forum)
Proc. IRE. Proceedings of the Institute of Radio Engineers
Proc. London Math. Soc., 2nd Ser.; 3rd Ser. Proceedings of the London Mathematical Society, 2nd Series; 3rd Series
Proc. Phys. Soc., Sect. B. Proceedings of the Physical Society (British), Section B
Proc. Royal Netherlands Acad. Sci., Amsterdam, Ser. A; Ser. B; Ser. C. Proceedings of the Royal Netherlands Academy of Sciences at Amsterdam, Series A (Mathematical Sciences); Series B (Physical Sciences, containing, e.g., Astronomy, Chemistry, Geology, Physics, Technical Sciences); Series C (Biological and Medical Sciences)
Proc. Royal Soc. (Edinburgh). Proceedings of the Royal Society (Edinburgh)
Proc. Royal Soc. (London), Ser. A. Proceedings of the Royal Society (London), Series A (Mathematical and Physical Sciences)
Prod. Eng. Product Engineering
Prof. Engr. Professional Engineer
Promotionsarb. Promotionsarbeiten, École Polytechnique Fédérale (Zurich)
Purdue U. TR. Purdue University, Technical Reports

Quadrangle
Quart. Appl. Math. Quarterly of Applied Mathematics
Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics
Quart. J. Royal Meteorological Soc. Quarterly Journal of the Royal Meteorological Society

Radio & TV News. Radio & Television News
Radio-Electronic Eng. Radio-Electronic Engineering Section (formerly a section in **Radio & TV News**)
Radio Tech. Comm. Aeronautics, Papers. Radio Technical Commission for Aeronautics, Papers
RAND Corp. Transl. The RAND Corporation, Translations
RCA Rev. RCA Review
La Recherche Aéronautique (Paris)
Rend. Accad. Naz. dei Lincei, Classe Sci. Fis. Mat. e Nat. Rendiconti dell'Accademia Nazionale dei Lincei, Classe di Scienze Fisiche, Matematiche e Naturali (Italy)
Rensselaer Polytech. Inst. Dept. Aero. Eng. TR. Rensselaer Polytechnic Institute, Department of Aeronautical Engineering, Technical Reports
Rep. Inst. Sci. & Tech. Report of the Institute of Science and Technology (Tokyo)
Republic Av. Rep. Republic Aviation Corporation, Reports
Res. Trends (Cornell Aero. Lab.). Research Trends (Cornell Aeronautical Laboratory, Inc.)
Rev. Aero. Revista de Aeronáutica (Madrid)
Rev. Nac. Aero. Revista Nacional de Aeronautica (Buenos Aires)
Rev. Sci. Instr. Review of Scientific Instruments
Rev. Universelle des Mines. Revue Universelle des Mines (Liege, Belgium)
Reynolds Metals Tech. Adviser. Reynolds Metals Technical Adviser
Ricerca Sci. La Ricerca Scientifica (Rome)
Riv. Aero. Rivista Aeronautica (Rome)
Rockets
Rolls-Royce Bul. Rolls-Royce Bulletin
Rozprawy Inżynierskie, Instytut Podstawowych Problemów Techniki, Polska Akademia Nauk, Warsaw
Ryan Reporter

EEMCo

technical bulletin

a New *MOTOR*

for hydraulic pump in a guided missile

EEMCO Model D-638 was designed and produced for a leading airframe manufacturer for use in guided missiles where greatest power output per pound of weight is imperative. Specifications called for a 400 cycle A.C. motor operating on 200 volts, 20 amperes, at 2250 r.p.m. and a continuous duty cycle of 3.0 seconds at 6.5 HP and 15.0 seconds at 1.5 HP. **EEMCO's D-638,** weighing 17.5 lbs., was the answer. It also has a continuous rating at 5 HP of 2300 r.p.m., at 15.8 amperes. Complies with U. S. A. F. specification #32590 for 400 cycle A.C. motors. We invite your inquiry on adaptation of Model D-638 for other uses.

Designers and producers of motors, linear and rotary actuators.

SPECIFICATIONS ★ TYPE D-638

Weight: 17.5 pounds ★ **Maximum Capacity:** 6.5 HP

Volts: 200 A.C. ★ **Amperes:** 20 at 6.5 HP ★ **Cycles:** 400

Duty cycle: 3.0 seconds at 6.5 HP
15.0 seconds at 1.5 HP

Continuous rating: 5 HP at 2300 r.p.m., 15.8 amperes, 200 volts.

Electrical Engineering and Manufacturing Corp.

4612 West Jefferson Boulevard
Los Angeles 16, California

Saab Sonics (Sweden)
Saab TN. Saab Technical Notes
SAE Aero. Info. Rep. Society of Automotive Engineers, Aeronautical Information Report
SAE J. SAE Journal
SAE Preprints; Papers. Society of Automotive Engineers, Preprints; Papers
Sailplane & Glider
Saro Prog. Saro Progress
Schweissen und Schneiden (Germany)
Sci. Mo. The Scientific Monthly
Science
Sheet Metal Ind. Sheet Metal Industries
Shell Av. News. Shell Aviation News
Siemenstadt, Mitt. Forsch. Lab. Siemenstadt, Mitteilung und Forschung Laboratorium (Germany)
Skyline. (North American Aviation, Inc.)
Skyways
SNCASO Papers. Société Nationale de Constructions Aéronautiques du Sud-Ouest, Papers
Soaring
Solar Blast
SPE J. Society of Plastics Engineers, Journal
Sperry Gyroscope Rep. Sperry Gyroscope Company, Reports
Sperry Rev. Sperry Review
Sperryscope
Stahl und Eisen (Düsseldorf, Germany)
Stanford Res. Inst. Res. Ind. Stanford Research Institute, Research for Industry
State Coll. Ia. Eng. Exp. Sta. TR. State College of Iowa, Engineering Experiment Station, Technical Reports
Steel Horizons
Steel Processing
Stockholm, KTH AERO TN. Stockholm, Kungliga Tekniska Högskolan, Institutionen för Flygteknik, Technical Notes
Stockholm, KTH IBS Medd. Stockholm, Kungliga Tekniska Högskolan, Institutionen för Byggnadsstatik, Meddelanden
Structural Engr. Assn. Calif. Rep. Structural Engineers Association of California, Reports
Stuttgart Tech. Hochsch. Stuttgart Technische Hochschule (Germany)
Sverdrup & Parcel Transl. Rep. Sverdrup & Parcel, Inc., Translation Reports
Sweden, Flygtekniska Försöksanstalten, FFA Medd. (The Aeronautical Research Institute of Sweden, Reports)
Syracuse U. Transp. Conf. Papers. Syracuse University, Transportation Conference, Papers

Taylor Tech. Taylor Technology
Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques (Paris)
Tech. Rev. Technology Review
Teknisk Ukeblad (Norway)
Tele-Tech
Tôhoku U. (Japan) Rep. Inst. High Speed Mech. Tôhoku University, Sendai, Japan, The Reports of the Institute of High Speed Mechanics. The Science Reports of the Research Institutes, Series B (Technology)
Tool Engr. Tool Engineer
Trans. AIEE. Transactions of the American Institute of Electrical Engineers
Trans. ASME. Transactions of the American Society of Mechanical Engineers
Trans. Inst. Welding. Transactions of the Institute of Welding
Trans. IRE Prof. Group on Microwave Theory & Techniques. Transactions of the Institute of Radio Engineers, Professional Group on Microwave Theory and Techniques
Trans. Soc. Inst. Tech. Transactions of the Society of Instrument Technology
Transp. & Commun. Rev. Transport and Communications Review
Transport (India)
Trend in Eng. The Trend in Engineering

U. Ark. Engr. Exp. Sta. Bul. University of Arkansas, Engineering Experiment Station, Bulletin
U. Calif. Pubs. in Eng. University of California, Publications in Engineering
U. Ill. Bul. University of Illinois, Bulletins
U. Ill. Eng. Exp. Sta. Bul.; TR. University of Illinois, Engineering Experiment Station, Bulletins; Technical Reports
U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. University of Maryland, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series
U. Mich. Eng. Res. Inst. Rep. University of Michigan, Engineering Research Institute, Reports
U. Mich. Icing Res. Cen. Rep.; Transl. University of Michigan, Icing Research Center, Reports; Translations
U. Minn. Inst. Tech. Dept. Aero. Eng., Res. Rep. University of Minnesota, Institute of Technology, Department of Aeronautical Engineering, Research Reports
U. Toronto Inst. Aerophys. Rev.; Rep. University of Toronto, Institute of Aerophysics, Review; Reports
U. Wash. Eng. Exp. Sta. Bul.; Reprints. University of Washington, Engineering Experiment Station, Bulletins; Reprints
U. Wis. NRL Dept. Chem. Rep. University of Wisconsin, Naval Research Laboratory, Department of Chemistry, Reports
United Air Lines News
U.S., Bur. Mines Bul.; Rep. Invest. United States, Bureau of Mines, Bulletin; Report of Investigations
U.S., CAA AEE Rep. United States, Civil Aeronautics Administration, Airframe and Equipment Engineering Reports
U.S., CAA TDR. United States, Civil Aeronautics Administration, Technical Development Reports
U.S., Forest Prod. Lab. Rep. United States, Forest Products Laboratory, Madison, Wis., Reports
U.S., NACA Rep.; RM; TM; TN. United States, National Advisory Committee for Aeronautics, Report; Research Memorandum; Technical Memorandum; Technical Notes
U.S., NADC Rep. U.S., Naval Air Development Center, Reports
U.S., NAES Rep. United States, Naval Air Experiment Station, Reports
U.S., Nav. Sch. Av. Med., Pensacola, Fla., Project Rep. United States, Naval School of Aviation Medicine, Naval Air Station, Florida, Project Reports
U.S., NavBuAer RDR. United States, Navy Department, Bureau of Aeronautics, Research Division Reports
U.S., NAVORD Rep. United States, Naval Ordnance, Reports
U.S., Navy Dept., David W. Taylor Model Basin, Rep.; Transl. United States, Navy Department, David W. Taylor Model Basin, Reports; Translations
U.S., NBS J. Res. United States, National Bureau of Standards, Journal of Research
U.S., NBS Sum. TR. United States, National Bureau of Standards, Summary Technical Reports
U.S., NBS Tech. News Bul. United States, National Bureau of Standards, Technical News Bulletin
U.S., NRL Rep. United States, Naval Research Laboratory, Reports
U.S., ONR Res. Rep. United States, Office of Naval Research, Research Report (monthly)
U.S., ONR Special Devices Cen. TR. United States, Office of Naval Research, Special Devices Center, Technical Reports
U.S., Weather Bur. Mo. Weather Rev. United States, Weather Bureau, Monthly Weather Review
U.S. AEC Rep. United States Atomic Energy Commission, Reports
U.S. Air Serv. U.S. Air Services
U.S. Armed Forces Med. J. United States Armed Forces Medical Journal
U.S. Naval Inst. Proc. United States Naval Institute, Proceedings
U.S. Steel Lubricants Testing Lab. Rep. United States Steel Lubricants Testing Laboratory, Reports
USAF AMC Eng. Div. Aero Med. Lab. TR. United States Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Technical Reports
USAF APG Rep. United States Air Force, Air Proving Ground, Reports
USAF Arctic Aeromed. Lab. Project Rep. United States Air Force, Arctic Aeromedical Laboratory, Alaska, Project Reports
USAF MATS Rep.; Papers. United States Air Force, Military Air Transport Service, Reports; Papers
USAF SAM Rep. United States Air Force, School of Aviation Medicine, Reports
USAF TR. United States Air Force, Technical Reports

Va. J. Sci. The Virginia Journal of Science
VDE Fachber. Verein Deutscher Elektrotechniker, Fachberichte (Germany)
VPI Eng. Exp. Sta. Ser. Bul. Virginia Polytechnic Institute, Engineering Experiment Station, Series Bulletin
VTH. Vliegtuigbouwkunde Technische Hogeschool (Delft)

W. U. Tech. Rev. Western Union Technical Review
Welding J. Welding Journal
Welding J. Res. Suppl. Welding Journal, Research Supplement
Welding Res. Welding Research (London)
Weltraumfahrt (Frankfurt am Main)
Western Av. Western Aviation
Westinghouse Engr. Westinghouse Engineer
Whites' Av. Whites' Aviation
Wireless Engr. Wireless Engineer
Wireless World
WMO Bul. World Meteorological Organization Bulletin

Z. für Elektrochemie. Zeitschrift für Elektrochemie (Halle, Germany)
Z. für Instrumenkunde. Zeitschrift für Instrumenkunde (Berlin)
Z. VDI. Zeitschrift des Vereins Deutscher Ingenieure (Berlin)
ZAMM. Zeitschrift für angewandte Mathematik und Mechanik (Berlin)
ZAMP. Zeitschrift für angewandte Mathematik und Physik (Zurich)
ZFW. Zeitschrift für Flugwissenschaften (Braunschweig)
Zhur. Tekh. Fiz. Zhurnal Tekhnicheskoi Fiziki (Moscow)
Zurich Tech. U. Papers. Zurich Technological University, Papers
ZWB UM. Zentrale für Wissenschaftliches Berichtswesen über Luftfahrtsforschung, Untersuchungen und Mitteilungen

NEW FJ-4 FURY FEATURES "pump that couldn't be built"

Intended for combat at near sonic speeds, North American Aviation's FJ-4 Fury jet fighter is characterized by thin wings. The carrier-based craft, first flown on October 28, 1954, relies on a new-type Pesco fuel transfer pump and three Pesco submerged fuel pumps.

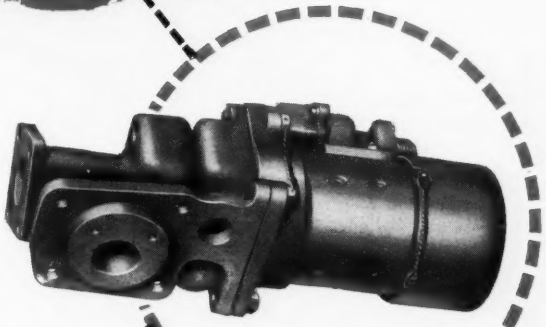
The U.S. Navy's newest jet fighter, the North American Aviation FJ-4 Fury, uses a revolutionary new Pesco pump in a line-mounted fuel transfer application. This—the pump that couldn't be built—is the first centrifugal impeller type pump ever perfected for such use.

The extremely thin wings of the FJ-4 prevented use of submerged fuel pumps in the wing tanks, so Pesco engineered the so-called "impossible" pump. A radically new Pesco-designed impeller permits the pump to overcome long inlet line losses and deliver a full flow of JP-4 fuel up to 45,000 feet altitude. The pump is instantly self-repriming should it become unprimed during manuevers.

Designed for a 1200 hour overhaul cycle, this motor-driven pump is powered by a Pesco-built DC Electric Motor. Precise and powerful, it weighs only 7.4 pounds and its 11″ x 5″ x 5″ envelope fits into a close-tolerance fuselage location.

Three submerged fuel pumps in the fuselage tank are other Pesco components of the fuel system which supplies the Wright J-65-W4 power plant.

The "pump that couldn't be built" typifies Pesco's continued success in solving difficult aircraft pumping problems. If you have such a problem, take advantage of the development facilities, engineering experience and greatly increased manufacturing capacity of Pesco. Call or write: PESCO, 24700 North Miles Road, Bedford, Ohio.



Model 122913-010 Fuel Transfer Pump was specially developed by Pesco for FJ-4. Able to pump boiling fuel, run "dry" for 15 hours and reprime itself, this pump performs a function previously considered impossible for a line-mounted aircraft fuel pump.

engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD • BEDFORD, OHIO

Aerodynamics

List of Reports, Second Edition; Corrections and Supplement 1954. *Netherlands, NLL Rep.*, July, 1954. 78 pp. 781 refs. Author and subject bibliography with breakdowns on: general aerodynamics; flutter and theoretical aerodynamics; materials; structures; and flight mechanics.

Boundary Layer & Thermoaerodynamics

An Approximate Method of Solution of the Compressible Laminar Boundary Layer with Heat Transfer. Hidesato Itō. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 32, 1954, p. 11. 12 refs. Generalization of the Pohlhausen method for an incompressible fluid applied to the case of a flat plate; calculation of the laminar boundary layer around an elliptic cylinder with thickness ratio 1:10 for two different surface temperatures of the fluid at the Prandtl Number of 0.73.

The Effects of Surface Irregularities on Transition in the Laminar Boundary Layer. E. H. Cowled. *Australia, ARL Rep. A.86*, Apr., 1954. 73 pp. 19 refs. Review of the literature; development of a method to predict transition up to high-flight Reynolds Numbers and to assess the effect of multiple disturbances.

Experimental Determination of Boundary-Layer Transition on a Body of Revolution at M = 3.5. James R. Jedlicka, Max E. Wilkins, and Alvin Seiff. *U.S., NACA TN 3342*, Oct., 1954. 56 pp. 18 refs.

An Experimental Determination of Flat Plate Recovery Factors for Mach Numbers Between 1.90 and 3.14. R. H. Shoulberg, J. A. F. Hill, and M. A. Rivas, Jr. *J. Aero. Sci.*, Nov., 1954, p. 763. 22 refs. OAR-sponsored research program at the MIT Naval Supersonic Lab. to investigate fundamental aspects of aerodynamic heating, with emphasis on wind tunnel design factors.

Heat Transfer by Free Convection from Horizontal Cylinders in Diatomic Gases. I—Determination of Heat-Transfer Law for Horizontal Cylinder from Tests with Particular Account Taken of the Temperature Characteristic Te. II—Theoretical Solution of the Boundary Equations for the Horizontal Cylinder (Case of Steady Motion). III—Hydrodynamic and Thermal Comparison Between Vertical Plate and Horizontal Cylinder for Free Convection and for Plate in Parallel Flow. IV—The Occurrence of Turbulence in Free Flow About a Horizontal Cylinder and Along a Vertical Plate. R. Hermann. *(Z. VDI Forschung*, No. 379, 1936, p. 1.) *U.S., NACA TM 1366*, Nov., 1954. 73 pp. 27 refs. Translation.

Improved Solutions of the Falkner and Skan Boundary-Layer Equation. A. M. O Smith. *IAS SMF Fund Paper FF-10*, Mar., 1954. 36 pp. 13 refs. Members, $0.75; nonmembers, $1.25.

Observations sur un Critère de Décollement Laminaire dans la Couche-Limite Tridimensionnelle. E. A. Eichelbrenner and A. Oudart. *La Recherche Aéronautique*, July-Aug., 1954, p. 3. In French. Observations on a criterion of laminar separation in the three-dimensional boundary layer; analysis of the problem for the case of an elliptic yawed cylinder.

Theory of Heat Transfer of Heated or Cooled Body in High Speed Gas Flow. I. Tatsuo Yuge. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 35, 1954, p. 73. Investigation of the basic problem taking into account the compressibility of the fluid, the frictional forces, and the relation between the distribution of the heat transfer and the pressure in the laminar boundary layer along the surface of the heated two-dimensional bodies of various shapes.

Transition-Point Fluctuations in Supersonic Flow. John C. Evvard, Maurice Tucker, and Warren C. Burgess, Jr. *J. Aero. Sci.*, Nov., 1954, p. 731. 15 refs. NACA experimental investigation; includes a calculation of a hypothesized instantaneous surface-temperature distribution for eight sets of measurements by means of the statistical distribution functions obtained from schlieren data and surface temperatures as time-averaged by the surface thermocouples.

Control Surfaces

Rolling Characteristics of Narrow-Delta Cruciform Wings with Canard-Delta or Trailing-Edge Ailerons. Kelsey Walker, Jr. *Douglas Rep. SM-18309*, Mar., 1954. 24 pp.

Fluid Mechanics & Aerodynamic Theory

On the Average Second Moment of the Energy Spectral Intensity. Tse-Sun Chow. *Quart. Appl. Math.*, Oct., 1954, p. 287. Analysis for the case of an incompressible viscous fluid with the domain of flow extending to infinity.

Theoretical Research on Transonic Flow. II. Mutsumi Honda. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 33, 1954, p. 37. Application of the hodographic method to the transonic thin-airfoil theory in an expression of the stream function to calculate the flow of compressible fluids around symmetrical biconvex airfoils.

Influence d'un Point d'Inflexion à l'Arrière d'un Profile en Écoulement Transsonique. R. Michel, F. Marchaud, and J. Le Gallo. *La Recherche Aéronautique*, July-Aug., 1954, p. 15. In French. Experimental study of the influence of a point of inflection behind a profile in transonic flow on the nature of the flow, particularly near the speed of sound.

On the Non-Steady Motions of a Rigid Body in an Ideal Fluid. G. W. Morgan. *Quart. Appl. Math.*, Oct., 1954, p. 277. ONR-sponsored investigation at Brown U. of a hydrodynamic problem concerned with the equations of motion of the body and the inviscid and incompressible fluid in terms of the kinetic energies.

On the Theory of Discontinuous Flows. R. Eppler. *(Stuttgart Tech. Hochsch.* [Germany], *Dissertation*, 1951.) *Gt. Brit., MOS TIB/T4307*, July, 1954. 61 pp. 16 refs. Translation. Extension of existing theory for the flat plate set perpendicular to the direction of flow, with an analysis of flows within the scope of the existing theory; investigation of flows around given contours with a given wake pressure, and a generalization to other wake pressures.

Schnell arbeitende, lineare Charakteristiken-Verfahren für axiale und schräge Überschallanströmung um Rotationskörper mit Ringflächen. Siegfried Erdmann and Klaus Oswatitsch. *ZFW*, Aug., 1954, p. 201. In German. Development of a new method of characteristics applicable to the linear potential equation of flow over bodies of revolution under oblique attack as relations of proportionality between variables suitably chosen on the Mach lines.

O Procesach Wymiany Ciepła w Poruszającym się Aerosolu (Sur le Processus d'Échange de Chaleur dans un Aérosol en Mouvement). H. Jarzyna and M. Łunc. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 305. In Polish, with summaries in French and Russian. Study of the heat-transfer problem of an aerosol in motion for the particular case of an aerosol crossing a surface of discontinuity or a shock wave.

Harmonic Wave Solutions of the Non-Linear Vorticity Equation for a Rotating Viscous Fluid. Shih-Kung Kao. *J. Meteorology*, Oct., 1954, p. 373. 11 refs. ONR-sponsored study of the fluid motion problem, including the effects of the viscosity and the height dependency of velocity components.

Symmetrical Disturbances in a Thin Layer of Fluid Subject to a Horizontal Temperature Gradient and Rotation. H.-L. Kuo. *J. Meteorology*, Oct., 1954, p. 399. 11 refs. USAF-sponsored investigation at MIT of the basic fluid motion problem with its convective factors.

Torsion of a Shaft with a Toroidal Cavity. G. Weiss and L. E. Payne. *J. Appl. Phys.*, Oct., 1954, p. 1321. 13 refs. USAF-supported investigation of the basic problem of an n dimensional axially symmetric body in a uniform stream of a nonviscous, incompressible fluid flowing parallel to the axis of symmetry of the body.

Détermination Théorique de l'Écoulement d'un Fluide Derrière une Onde de Choc Détachée. Henri Cabannes. *France, ONERA NT 5*, 1951. 27 pp. 10 refs. In French. Theoretical determination of the behavior of a fluid flow behind a detached shock wave.

An Experimental Investigation of the Interaction of a Shock Wave with a Subsonic Stream Bounded by a Wall. D. W. Holder, A. Chinneck, and G. E. Gadd. *Philos. Mag. (7th Ser.)*, Oct., 1954, p. 997. Analytical study in the NPL Aerodynamics Div.

Pseudotransonic Similitude and First-Order Wave Structure. Wallace D. Hayes. *J. Aero. Sci.*, Nov., 1954, p. 721. 14 refs. Theoretical extension of the von Kármán transonic similitude for supersonic flow, with appropriate forms of similitude for the flow about slender bodies, two-dimensional flow, and the flow at a distance from finite systems.

Shock Waves and Thermal Discontinuities in Supersonic Flows. I. Jean J. Ginoux. *Interavia*, No. 10, 1954. p. 704. Simplified review of basic principles, with references to experimental studies in the Rhode-St.-Genèse Wind Tunnel, Brussels.

On the Determination of Certain Basic Types of Supersonic Flow Fields. Carlo Ferrari. *(Rend. Accad. Naz. dei Lincei, Classe Sci. Fis. Mat. e Nat.*, Ser. VIII, Vol.

Acceleration!

MEASURE IT WITH A GIANNINI ACCELEROMETER

Magnetically and hydraulically damped units available. High outputs can be used to actuate recording, indicating or telemetering devices directly without amplification. Precious metal potentiometer coil and brushes used for long life and low noise. Unaffected by altitude or humidity. Will operate under conditions of high vibration. *Write for information.*

MODEL 24117P
Small, compact, lightweight. Oil damped, pressurized. Ranges 2.5G to 20G. Resistances 2000 ohms and 5000 ohms.
MODEL 24118
Ranges 1G to 30G. Resistances 1000 ohms to 20,000 ohms. Inert gas filled or oil filled, single or dual outputs, linear or functional.

Giannini

G. M. GIANNINI & CO. INC.
Airborne Instrument Division
PASADENA 1, CALIFORNIA

VII, No. 6, 1949?) *U.S., NACA TM 1381*, Nov., 1954. 17 pp. Translation.

Corrélation dans le Temps et l'Espace, avec Filtre de Bande, en Aval d'une Grille de Turbulence. A. Favre, J. Gaviglio, and R. Dumas. *La Recherche Aéronautique*, July-Aug., 1954, p. 7. In French. Experimental correlation in time and space of longitudinal fluctuations of turbulent speeds downstream of a grillework in a wind tunnel, taking into account the influence of the constituents at low frequencies.

Internal Flow

Cavitation Tests on Hydrofoils in Cascade and its Theoretical Basis of Experiment. Fukusaburō Numachi. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 39, 1954, p. 125. Investigation using a specially designed cavitation tunnel of the characteristics of three types of hydrofoils in cascade under both normal and cavitating conditions.

Experimental Study of Flow Between Centrifugal Pump Shrouds. H. N. Tyson, Jr. *CIT Hydrodynamics Lab. Rep. E-19.6*, July, 1954. 26 pp. 13 refs. ONR-sponsored internal flow investigation to determine the internal velocity distributions in the shroud passage of a well-designed impeller of the Francis type.

The Jettisoning of Liquids from an Airplane in Flight. F. R. Riddell. *Douglas Rep. SM-18279*, Mar., 1954. 62 pp. Development of a basis for nozzle design and model testing, taking into account the flow process of formation and spreading of the spray of liquid drops.

Liquefaction of Air in the Langley 11-Inch Hypersonic Tunnel. Charles H. McLellan and Thomas W. Williams. *U.S., NACA TN 3302*, Oct., 1954. 36 pp. 16 refs. Investigation to determine the nature of the condensation process occurring at low stagnation temperatures and the effect of stagnation temperature on the flow in two Mach Number 7 nozzles.

Summary Report on the Research of Cavitation Phenomena Obtained hitherto by our Institute. I—Cavitation Tests on Single Hydrofoils for Blade Elements. II—Cavitation Tests on Hydrofoils Arranged in Cascade. F. Numachi. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 40, 1954, p. 159. 31 refs.

Theory on the Mutual Interference of Blade Elements in a Cascade. Hitoshi Murai. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 31, 1954, p. 1. Calculation of the lift coefficient of an airfoil profile with arbitrary small camber and thickness arranged in a cascade, with an evaluation of the zero-life angle, the interference factor, and the surface velocity distribution of the profile.

Stability & Control

Calculated Subsonic Span Loads and Resulting Stability Derivatives of Unswept and 45° Sweptback Tail Surfaces in Sideslip and in Steady Roll. M. J. Queijo and Donald R. Riley. *U.S., NACA TN 3245*, Oct., 1954. 110 pp.

Effects of Certain Steady Motions on Small-Disturbance Airplane Dynamics. Malcolm J. Abzug. *J. Aero. Sci.*, Nov., 1954, p. 749. Derivation of linearized

with the

TEMPCAL

TEST OVER-HEAT DETECTORS and WING ANTI-ICE SYSTEMS ... RIGHT ON THE PLANE!

The TEMPCAL checks thermal switch and individual thermocouple ACCURACY.

TEMPCAL *functionally tests* thermal switches with their fire detection and anti-ice systems at their *operating temperatures* right on the aircraft ... and its relay circuit makes it possible to check *switches only* on or off the plane. Additionally, using a selected part of the TEMPCAL circuit, cylinder head temperature thermocouples and their circuits to the flight deck instrument can be checked.

ACCURACY—TEMPCAL Tester temperature readings are made on a highly accurate potentiometer; guaranteed accuracy is ±5°F with temperatures ranging from 0° to 800°F. Heater probes used for cylinder head thermocouples are guaranteed accurate to ±4°C at 0° to 300°C operating temperatures.

FASTER MAINTENANCE CHECKS—It is no longer necessary to take thermal switches to the "lab" for testing. TEMPCAL probes reach a temperature of 800°F in about 8 minutes for quick maintenance checks *on the aircraft.*

The production or maintenance engineer, pilot *and cost accountant* will readily realize the savings and safety factors resulting from TEMPCAL use. We invite inquiries concerning the TEMPCAL (as well as the JETCAL ..... for jet engine EGT system accuracy) *and will be glad to have our engineering department help solve your heat problems.*

b&h INSTRUMENT

B & H INSTRUMENT Company, Inc.
1009 Norwood
FORT WORTH 7, TEXAS

equations for the cases of four conditions of maneuvering flight.

Suggested Criterion of Longitudinal Stability in Stalling of Swept-back Wings. J. E. de Krasinski. (*Aero. Argentine Commun. & Inform.*, n.d.) *Gt. Brit., MOS TIB/T4295*, July, 1954. 35 pp. 28 refs. Translation.

Wings & Airfoils

Experimentelle und theoretische Untersuchungen an symmetrisch angeströmten Pfeil- und Deltaflügeln. E. Truckenbrodt. *ZFW*, Aug., 1954, p. 185. 11 refs. In German. USAF-supported theoretical and experimental comparative investigation of the characteristics of swept-back and delta wing configurations.

Generalized Aerodynamic Forces on the Delta Wing with Supersonic Leading Edges. J. Walsh, G. Zartarian, and H. M. Voss. *J. Aero. Sci.*, Nov., 1954, p. 739. 14 refs. Use of the strip theory on a semiphysical basis to determine exactly the contribution of any flexible or rigid-body mode.

A Method for Obtaining Profile Form with Prescribed Pressure Distribution. Hisashi Kikuchi. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 38, 1954, p. 113. Development of an approximate method to calculate the thickness distribution and the mean camber line of the required form.

Swept Wings in Supersonic Flight. S. B. Gates. *Gt. Brit., ARC R&M 2818* (Dec., 1946), 1954. 10 pp. BIS, New York. $0.75. Assessment of aerodynamic merits.

Aeroelasticity

The Analysis and Synthesis of Vibrating Systems. R. E. D. Bishop. *J. RAeS*, Oct., 1954, p. 703. Conceptual principles of a "dynamic flexibility" receptance method applied to the study of the natural frequency characteristics of the components of complex oscillatory systems, including engines, compressors, and pumps.

Considerations on the Effect of Wind-Tunnel Walls on Oscillating Air Forces for Two-Dimensional Subsonic Compressible Flow. Harry L. Runyan and Charles E. Watkins. (*U.S., NACA TN 2552*, 1951.) *U.S., NACA Rep. 1150*, 1953. 7 pp. Supt. of Doc., Wash. $0.15.

Control-Surface Flutter with the Stick Free. Appendix I—Technique of the Flutter Solutions. Appendix II—Stick-free Flutter with a Bob-weight Fitted to the Stick. Appendix III—Circuit Inertia Effects. H. Templeton. *Gt. Brit., ARC R&M 2824* (May, 1950), 1954. 22 pp. BIS, New York. $1.40.

Détermination par le Calcul et par Essais en Soufflerie des Vitesses Critiques de Vibration d'une Maquette Plane à Deux Degrés de Liberté: Rotation de l'Aile et Rotation de l'Aileron. J. Dorr. *France, ONERA NT 3*, 1951. 12 pp. In French. Wind-tunnel experimental investigation of the critical speeds of vibration of a model plane having two degrees of freedom; solution of the problem for the cases of rotation of a wing and of an aileron.

Détermination Théorique des Coéfficients Aérodynamiques d'une Structure Quelconque en Mouvement Vibratoire Harmonique. D. Hamel. *France, ONERA NT 6*, 1951. 48 pp. In French. Theoretical determination of the aerodynamic coefficients of the harmonic vibratory movements of an aircraft structure.

Essai d'Approximation des Forces Aérodynamiques en Régime Compressible à M = 0.7. S. Chopin. *La Recherche Aéronautique*, July-Aug., 1954, p. 21. In French. An approximate method to calculate the flutter characteristics at critical speeds of an aircraft.

Étude du Flutter en Régime Supersonique; Le Flutter Flexion-Torsion (Problème-plan). R. Weber and W. Ruppel. *France, ONERA NT 2*, 1951. 15 pp. In French. Study of the supersonic flexion-torsion flutter problem in two degrees of freedom.

Étude Théorique de la Réponse d'une Poutre Amortie à une Excitation Sinusoidale Appliquée à son Extrémité Libre. Madeleine Hourlier. *La Recherche Aéronautique*, July-Aug., 1954, p. 37. In French. Theoretical study of the harmonic response of a damped beam to a sinusoidal excitation applied to its free-end, with a determination of the constants in the case of a cantilever beam.

Extension of the Statistical Approach to Buffeting and Gust Response of Wings of Finite Span. H. W. Liepmann. *Douglas Rep. SM-15172*, Feb., 1954. 14 pp.

Lift and Moment Equations for Oscillating Airfoils in an Infinite Unstaggered Cascade. Alexander Mendelson and Robert W. Carroll. *U.S., NACA TN 3263*, Oct., 1954. 46 pp. 18 refs.

Lift Developed on Unrestrained Rectangular Wings Entering Gusts at Subsonic and Supersonic Speeds. Harvard Lomax. (*U.S., NACA TN 2925*, 1953.) *U.S., NACA Rep. 1162*, 1954. 16 pp. 20 refs. Supt. of Doc., Wash. $0.20. Analysis includes specific results for sharp-edged and triangular gusts and various wing-air density ratios.

On Structural Fatigue Under Random Loading. John W. Miles. *J. Aero. Sci.*, Nov., 1954, p. 753. 20 refs. Analytical investigation of the special case of panel failure under the fluctuating pressure of buffeting by a jet exhaust as part of the basic general problem.

Aeronautics, General

Aeronautical Research and Development in Sweden; Financial Background and Organization. Hans-Eric Löfkvist. *Aero. Eng. Rev.*, Dec., 1954, p. 68.

Aeronautical Technology in the U.S.S.R. J. W. Rizika. *Tech. Rev.*, Nov., 1954, p. 23. Appraisal of developments and research.

Airplane Design

Designing for Comfort. Henry Dreyfuss. *Interavia*, No. 10, 1954, p. 683, cutaway drawings. Appraisal of the problems and experience on the Lockheed Super Constellation.

Flying the Miles Sparrowjet. John Fricker. *The Aeroplane*, Oct. 8, 1954, p. 549, cutaway drawing. Performance, design, and other characteristics of the M.77.

The Lightweight Fighter. Joseph Goodyear. *Ordnance*, Nov.-Dec., 1954, p. 388. Appraisal of the trend toward lightness and simplicity of design.

Reverse Thrust Developments for Jet Transports. Joseph Sutter. (*SAE Natl. Aeronautic Meeting, New York, Apr. 12-15, 1954, Paper.*) *Auto. Ind.*, Oct. 1, 1954, p. 64. Abridged.

Turbo-Proposition from America. Stanley H. Evans. *The Aeroplane*, Oct. 8, 1954, p. 544, cutaway drawings. Developmental design, structural, operational, and other characteristics of the Convair Turboprop Transport Model 240.

Air Conditioning & Pressurization

Aircraft Air-Conditioning Systems; Higher Altitudes Bring New Demands. Walter C. Shaw. *Aero Dig.*, Oct., 1954, p. 50. Design problems affecting turbine aircraft.

Aircraft Heating Systems; Automatic Temperature Controls for Aircraft. Frank Glassow and W. F. Tice. *Aero Dig.*, Oct., 1954, p. 62. Evaluation of design techniques, problems, requirements, and trends.

Compressor Bleed Air Must Not Contaminate Pressurized Cabins. Langdon F. Ayres. (*SAE Summer Meeting, Atlantic City, N. J., June 9, 1954, Paper.*) *SAE J.*, Oct., 1954, p. 31. Report of a round table discussion on pressurization problems.

Cockpits

Designing the Cockpit for High-Speed Flight. S. N. Roscoe. *Aero. Eng. Rev.*, Dec., 1954, p. 47. Appraisal of basic problems and the need for experimental research on displays and controls in terms of human limiting factors.

Landing Gear

An Evaluation of an Accelerometer Method Obtaining Landing-Gear Drag Loads. Jerome G. Theisen and Philip M. Edge, Jr. *U.S., NACA TN 3247*, Oct., 1954. 22 pp.

An Experimental Investigation of the Effect of Wheel Prerotation on Landing-Gear Drag Loads. Dexter M. Potter. *U.S., NACA TN 3250*, Oct., 1954. 19 pp.

Experiments on Tail-Wheel Shimmy. O. Dietz and R. Harling. (*ZWB Forschungsbericht No. 1320*, Nov. 25, 1940, p. 1.) *U.S., NACA TM 1376*, Oct., 1954. 81 pp. Translation. Detailed investigations on the dependence of the shimmy tendency on trail, rolling speed, load, size of tires, ground friction, inclination of the swivel axis, the influence of devices with restoring effect on the tail wheel, and the friction damping required for prevention of shimmy.

The Influence of Wheel Spin-Up on Landing-Gear Impact. Appendix A—Proof That Spring-Back Motion Cannot Be Interrupted by Slipping of Tire. Appendix B—Modified Power-Series Solution for Lateral Deflection y of Shock Strut. W. Flügge and C. W. Coale. *U.S., NACA TN 3217*, Oct., 1954. 107 pp.

On Force-Deflection Diagrams of Airplane Shock Absorber Struts. I—Comparison of Diagrams with Linear and

Bendix-Pacific CYLINDRICAL ACCUMULATORS

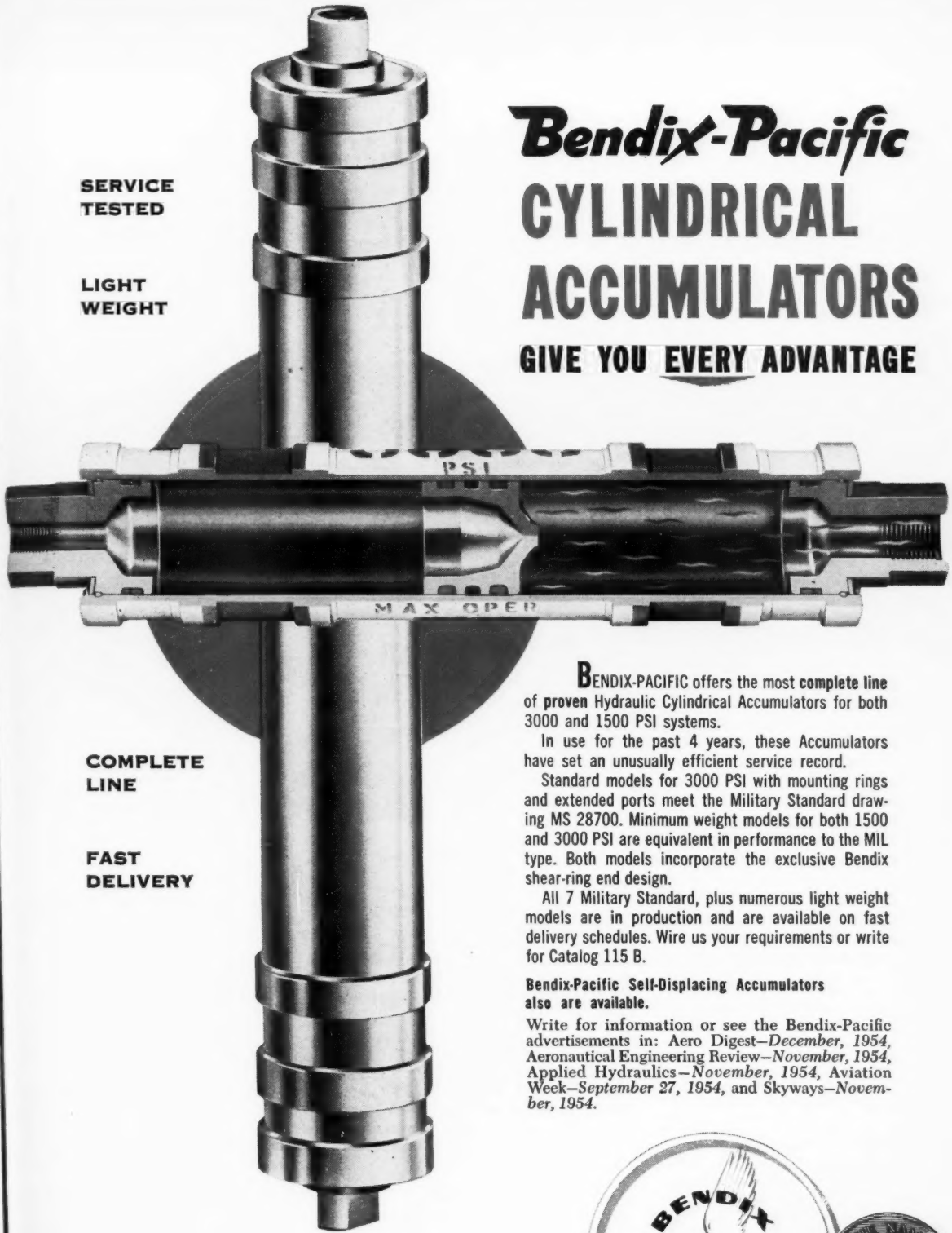
GIVE YOU EVERY ADVANTAGE

SERVICE TESTED

LIGHT WEIGHT

COMPLETE LINE

FAST DELIVERY



BENDIX-PACIFIC offers the most **complete line** of **proven** Hydraulic Cylindrical Accumulators for both 3000 and 1500 PSI systems.

In use for the past 4 years, these Accumulators have set an unusually efficient service record.

Standard models for 3000 PSI with mounting rings and extended ports meet the Military Standard drawing MS 28700. Minimum weight models for both 1500 and 3000 PSI are equivalent in performance to the MIL type. Both models incorporate the exclusive Bendix shear-ring end design.

All 7 Military Standard, plus numerous light weight models are in production and are available on fast delivery schedules. Wire us your requirements or write for Catalog 115 B.

Bendix-Pacific Self-Displacing Accumulators also are available.

Write for information or see the Bendix-Pacific advertisements in: Aero Digest—*December, 1954,* Aeronautical Engineering Review—*November, 1954,* Applied Hydraulics—*November, 1954,* Aviation Week—*September 27, 1954,* and Skyways—*November, 1954.*

BENDIX ★ PACIFIC

THE NAME Bendix AVIATION CORPORATION MEANS MORE

PACIFIC DIVISION • Bendix Aviation Corporation

11600 Sherman Way, North Hollywood, California

East Coast Office: 475 5th Ave., N.Y. 17

Export Division: Bendix International 205 E. 42nd St., N.Y. 17

Canadian Distributors: Aviation Electric, Ltd., Montreal 9

Quadratic Damping. II—Approximation Method for the Calculation of Force-Deflection Diagrams with a Nonlinear Spring Characteristic and Linear or Quadratic Damping. III—The Landing Impact of Oleo-Pneumatic Shock Absorbers. K. Schlaefke. (*Focke-Wulf Flugzeugbau GmbH, Bremen/Werkstoff-Versuchsabteilung, Tech. Berichte* [Germany], Feb. 15, Apr. 25, May 15, 1944, pp. 51, 105, 137.) *U.S., NACA TM 1373*, Nov., 1954. 49 pp. 17 refs. Translation.

Wing Group

The Architecture of Wings. R. Cox Abel. *Aeronautics*, Oct., 1954, p. 40. 10 refs. Survey of basic factors of structural design problems.

Wing Design for Practical High-Speed Aircraft. Donald W. Finlay. *Aero. Eng. Rev.*, Dec., 1954, p. 44. Appraisal of factors to insure a long life-span of utility for different designs.

Airports

Helicopter Stations

Planning for Urban Heliports. Robert Horonjeff and Howard S. Lapin. *U. Calif. Inst. Transp. & Traffic Eng. Res. Rep. 19*, June, 1954. 16 pp. 22 refs. Appraisal of the need for expanded ground facilities and related problems, with recommendations based on operating experience.

Traffic Control

Evaluation by Simulation Techniques of a Proposed Traffic Control Procedure for the New York Metropolitan Area. Clair M. Anderson and Charles E. Dowling. *U.S., CAA TDR 245*, Aug., 1954. 33 pp.

Aviation Medicine

Design Factors in Knobs and Levers for Making Settings on Scales and Scopes. A Summary Report. William L. Jenkins. *USAF WADC TR 53-2*, Feb., 1953. 5 pp. Experimental psychological findings on optimal time and movement ratios in different applications.

The Use of a Joy Stick in Making Settings on a Simulated Scope Face. William Leroy Jenkins and A. Charles Karr. *USAF WADC TR 53-430*, Mar., 1954. 7 pp. Results of psychological experiments at Lehigh U. on movement ratios in the operation of controls.

Computers

Adapting Digital Techniques for Automatic Controls. I. Bernard M. Gordon. *Elec. Mfg.*, Nov., 1954, p. 136. Characteristics of the "operational-digital" computational method; advantages and applications.

Computers—Brains of the Inertial System. Bernard Litman. *Av. Age*, Nov., 1954, p. 24. Study of design, operational, and other fundamental factors of analog and digital devices used for aircraft guidance.

An Introduction to Analog and Digital Computers. Jerry Roedel. *Ind. Sci. & Eng.*, Oct., 1954, p. 10. Review and classification of basic principles and operational characteristics of computational devices.

Massnahmen zur Erzielung kurzer und übersichtlicher Programme für Rechenautomaten. Klaus Samelson and Friedrich L. Bauer. *ZAMM*, July, 1954, p. 262. Study to abbreviate and simplify the general structure of programs of automatic computers by eliminating redundancy of information.

Photoelectric D-C Chopper for Guided Missiles. J. Schwartz and R. Solomonoff. *Electronics*, Nov., 1954, p. 162. Design of a unit to convert d.c. high-impedance millivolt signals into a.c. signals applicable to analog computers such as in aircraft systems with operational features including stability, long life, low noise, small size, and light weight.

Relay Time-Division Multiplier. Granino A. Korn and Theresa M. Korn. *Rev. Sci. Instr.*, Oct., 1954, p. 977. Theoretical basis, design, construction, and operational characteristics of a low-cost analog device for use with d.c. computers applied as differential analyzers.

Resistance-Network Analogues with Unequal Meshes or Subdivided Meshes. G. Liebmann. *Brit. J. Appl. Phys.*, Oct., 1954, p. 362.

A String-Net Analog for the Numerical Solution of the Equations of Laplace and Poisson. Peter L. Tea. *J. Franklin Inst.*, Oct., 1954, p. 287. 13 refs.

Education & Training

180-Degree Turn Experiment. Leslie A. Bryan, Jesse W. Stonecipher, and Karl Aron. *U. Ill. Inst. Av. Aero. Bul. 11*, 1954. 60 pp. 14 refs. Development of a practical pilot training curriculum based on a "flyout" and not a "fly through" procedure when faced with adverse weather conditions.

Electronics

Antennas

An Automatic Antenna Pattern Recorder. Lawrence Lechtreck. *Tele-Tech*, Nov., 1954, p. 88. Design of a closed-loop microwave servomechanism to measure the radiation pattern as the ratio between two power levels as a function of a third independent variable.

Circuits & Components

Component Design Trends; Iron-Core Transformers Run Smaller and Hotter. Frank Rockett. *Electronics*, Nov., 1954, p. 136. Review of materials used, fabricational techniques, operational characteristics, and other factors.

A Hidden Cause of Failure in Electronic Equipment: Metal Whiskers. S. M. Arnold. (*Electronic Components Symposium, Washington, D.C., May 4–6, 1954, Paper.*) *Elec. Mfg.*, Nov., 1954, p. 110.

The Phantastron. William L. Roberts. *Radio-Electronic Eng.*, Nov., 1954, p. 12. Design of a triggering circuit for producing a square wave of controllable yet highly stable duration; applications include radar and pulse circuitry.

Tunable Audio Filters. Geza Zelinger. *Electronics*, Nov., 1954, p. 173. Development by the DSRD (Israel) Electronics Lab. of a clamped resonant bar as an electromechanical filter using an electromagnet energized from a variable d.c. source for the 60–700 cycle range; applications include telemetering and control circuits.

Communications

Aircraft Communication Systems; Electronic Component Design Progress. Harvey A. Senior. *Aero Dig.*, Oct., 1954, p. 68.

Communications for Missile Testing. W. O. Brooks and D. L. Stephenson. *Radio-Electronic Eng.*, Nov., 1954, p. 7. Design study of the facilities at Patrick AFB, Fla., with circuit diagrams.

Construction Techniques

Welded Joints on Diodes Reduce Computer Bulk. S. G. Lutz. *Electronics*, Nov., 1954, p. 154. Development of assembling technique for complex electronic components by the Hughes Aircraft Miniaturization Group.

Delay Lines

Pulse Frequency Multiplication and Division by Delay Lines. Heinz Zemanek. *Wireless Engr.*, Oct., 1954, p. 264.

Dielectrics

Analyses of Basic Dielectric Amplifier Circuits. Shou-Hsien Chow. *J. Appl. Phys.*, Oct., 1954, p. 1297. Study of two basic types of circuits and of steady-state and transient responses.

Analysis of Propagating Modes in Dielectric Sheets. Leonard Hatkin. *Proc. IRE*, Oct., 1954, p. 1565.

Properties of Plasticizer and Their Relation to Electrical Compounding. J. J. Morris and W. J. Canavan. *Elec. Eng.*, Nov., 1954, p. 1018.

Electronic Tubes

Effects of Cathode and Anode Resistance on the Retarding Potential Characteristics of Diodes. G. C. Dalman. *J. Appl. Phys.*, Oct., 1954, p. 1263. 15 refs.

Electron Tube Grid Currents. Advisory Group on Electron Tubes, Office of the Asst. Secy. of Defense Research & Development. *Tele-Tech*, Nov., 1954, p. 70. Analysis of the detrimental characteristics of six forms of grid current hazards related to equipment reliability.

Helix-Coupled Traveling-Wave Tubes. Peter D. Lacy. *Electronics*, Nov., 1954, p. 132. Design and development of the tubes for the 2,000–4,000 mc. range; circuit details, performance characteristics, and microwave applications.

Microwave Applications of Gas Discharges. Frank R. Arams. *Electronics*, Nov., 1954, p. 168. 16 refs. Analysis of means for electronically controlling microwave signals in such devices as radar switches, oscillators, and gyrators.

Velocity-Modulation Tubes—A Survey. W. F. Gibbons. *Proc. Inst. Electronics*, First Quarter, 1954, p. 6. 15 refs. Developmental review of basic principles, operational requirements, and circuit applications.

SENIOR STAFF

at Ramo-Wooldridge

1. Dr. Burton F. Miller
2. Dr. James C. Fletcher
3. Robert B. Muchmore
4. Dr. John M. Richardson
5. Dr. Howard S. Siefert
6. Robert J. Barrett, Jr.
7. William B. Hebenstreit
8. Dr. Ralph P. Johnson
9. Jack H. Irving
10. Dr. Louis G. Dunn
11. Dr. Eldred C. Nelson
12. A. J. F. Clement
13. Dr. Milton U. Clauser
14. V. G. Nielsen
15. Dr. Eugene M. Grabbe
16. Marion F. Thorne
17. Dr. Robert R. Bennett
18. Robert J. Hight
19. Dr. Andrew Vazsonyi
20. Emory Lakatos
21. Richard A. Hartley
22. Dr. Howard L. Engel
23. Dr. Donald L. Drukey

The Senior Staff of The Ramo-Wooldridge Corporation, shown above, is comprised of scientists, engineers, and science administrators with outstanding records of past performance in positions of responsibility. By means of meetings of the entire group, supplemented by frequent smaller sessions, these key men participate actively in the establishment of company plans and policies.

Existing project commitments require that the current rapid rate of expansion of the company continue throughout the coming year. Unusual opportunities, encompassing a wide variety of challenging research and development problems, exist for *additional* scientists and engineers who would like to participate in the development of a company in which, from the outset, all features of the organization and of the operational procedures are designed to be as appropriate as possible to their special needs.

The Ramo-Wooldridge Corporation

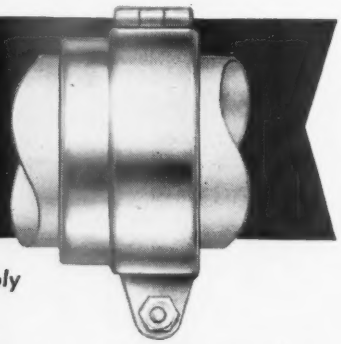
8820 BELLANCA AVENUE, LOS ANGELES 45, CALIFORNIA, DEPT. AER-2

POSITIONS ARE AVAILABLE FOR SCIENTISTS AND ENGINEERS IN THESE FIELDS OF CURRENT ACTIVITY

Guided Missile Research and Development
Digital Computer Research and Development
Business Data Systems Development
Radar and Control Systems Development
Communication Systems Development

Solve your hot air connector problems of weight, assembly and misalignment with

RUBBER TECK'S FLEXIBLE HOT AIR DUCT CONNECTOR



- ***Reduced weight***
- ***Quick assembly and disassembly***
- ***Wide Temperature Range***
- ***Allows ±4° misalignment.***

Efficient, simple and flexible. Weight reduction up to 75% over other devices. Absorbs vibration and torque and provides misalignment up to ±4°. Leak proof up to 400° F. and 125 PSI working pressure. Handles thermal expansion up to .150 inches. Available in either cadmium plated steel or anodized aluminum from ¼" to 6" O.D. standard tube sizes.

OTHER RUBBER TECK PRODUCTS: Flexible Breakaway Connectors • Duo-Seals • Rigid Duct Connectors • Flexible Fluid Line Connectors.
Write for data sheets on the complete line.

RUBBER TECK, Inc. GARDENA, CALIFORNIA

RUBBER TECK SALES & SERVICE CO.
8479 Higuera St., Culver City, Calif.
Texas 0-6836
5439 Harford Rd., Baltimore, Md.
Clifton 4-9671
60 East Bridge St., Berea, Ohio
Berea 4-7837

P. O. Box 584
El Cajon, California
Hickory 4-5493

RANDALL ASSOCIATES, INC.
Room 203, White Building,
Seattle, Washington

THOMPSON ENGINEERING SERVICE
554 Summit, Fort Worth, Texas
723 Broadway, Wichita, Kansas
4378 Lindell, St. Louis, Missouri

new
laboratory kit
saves design-in time

ACTUAL SIZE!

MICRODOT®

World's smallest COAX connectors, cables and assemblies

Specify world's most flexible line... Microdot Connectors and Mininoise® cable. 7 Kits now equipped with Microdot's unique½ oz. hand tool ...makes possible thousands of new coax combinations...including missile harnesses requiring minimum size and weight. Write for data.

MICRODOT
1326 FREMONT ST.
SO. PASADENA, CALIF.

ENGINEERS

Save your firm thousands of dollars in searching for data on ELECTRONIC TEST EQUIPMENT of interest to USAF.

By special permission data sheets on Research supported and monitored under our WADC, ARDC contract now available to manufacturers at low cost.

- Order your copy of a three volume set containing illustrated descriptive data sheets on 870 items procured for use by the U. S. Air Force.
- Contains 2400 (8½ x 11") pages recently brought up-to-date, mounted in 3 post expandable hard back binders.
- Price $100 per set plus postage while supply lasts. Orders accompanied by check filled as received with postage paid.

CARL L. FREDERICK
AND ASSOCIATES
Bethesda 14, Maryland

Magnetic Devices

Derivative Controlled Magnetic Amplifiers. A. D. Schnitzler. *Elec. Eng.*, Nov., 1954, p. 1021. Abridged. Applications include low-level signal circuits as in thermocouples and strain gages.

Magnetic Amplifiers With Inductive D-C Load. H. F. Storm. *Elec. Eng.*, Nov., 1954, p. 1007. Abridged.

Magnetostriction and Domain Structure of Materials for Use in Low-Noise Equipment. P. W. Neurath. *Elec. Eng.*, Nov., 1954, p. 991.

The Microwave Gyrator—A New Circuit Element. C. L. Hogan. *Tele-Tech*, Nov., 1954, p. 64. Ferromagnetic design of an antireciprocal component; applications include circulators, attenuators, modulators, and switches.

Theory of Strong Electromagnetic Waves in Massive Iron. William MacLean. *J. Appl. Phys.*, Oct., 1954, p. 1267. USAF-sponsored investigation at the Polytechnic Inst. of Brooklyn; solution of Maxwell's equations for the case of a rectangular magnetization curve; derivation of formulas for the depth of penetration and the wave impedance yielding a power input formula related to Rosenberg's quasi-theoretical expression.

Measurements & Testing

The Basis for Compromise Between Theoretical Performance and Operational Reliability. William D. McGuigan. *Aero. Eng. Rev.*, Dec., 1954, p. 65. Testing and related criteria for life expectancy of electronic components.

The Dampometer; An Electronic Apparatus for Automatic Recording of the Logarithmic Decrement and Frequency of Oscillations in the Audio and Sub-audio Frequency Range. Carl Olof Olsson and Kazimierz Orlik-Rückemann. *Electronic Eng.*, Oct., 1954, p. 420. For free oscillation measurements of the dynamic stability derivatives of airplane models in wind tunnels, with operational and circuit design details.

Problems Encountered in Calculating Reliability. Lucille F. Maier. *Aero. Eng. Rev.*, Dec., 1954, p. 52. Review of the Bell Aircraft electronic reliability program, with an appraisal of measuring and testing methods to evaluate parts, components, systems, and complete systems as in captive flights of missiles.

Testing Point-Contact Transistors for Pulse Applications. R. L. Wooley. *Elec. Eng.*, Nov., 1954, p. 981. Development of test methods taking into account measurements for dynamic and static conditions.

Navigation Aids

CAA Type II Automatic Flight and Navigation Equipment. John W. Watt and Logan E. Setzer. *U.S., CAA TDR 247*, Sept., 1954. 28 pp. Design and operational characteristics, with circuit details.

Development of a Variable-Parameter DME Interrogator. Richard C. Borden, Robert E. Carlson, John R. Hoffman, and Harold G. McMurtrey. *U.S., CAA TDR 246*, Sept., 1954. 12 pp. Design and operational characteristics of an airborne test unit (VPDI) to check performance, coverage, system interference, and multi-

path transmission of the distance-measuring-equipment transponder.

Networks

New Null Transmission Networks. E. M. Reid. *Electronic Eng.*, Oct., 1954, p. 444. Derivation of the null operating conditions of three frequency-sensitive networks.

Nyquist's Criterion; A Simple Derivation. O. P. D. Cutteridge. *Wireless Engr.*, Oct., 1954, p. 274. Includes a development of the "minimum-phase" stability criterion for network analysis.

Weighting Functions for Time-Varying Feedback Systems. J. A. Aseltine and R. R. Favreau. *Proc. IRE*, Oct., 1954, p. 1559. Development of an analytical technique leading to the adjoint system by a physical argument and avoiding the discussion of Green's functions to instrument a linear system using an analog computer.

Noise & Interference

Inductive Coordination. Nicholas Alchuk. *Radio-Electronic Eng.*, Nov., 1954, p. 18. Discussion of noise-frequency interference problems in terms of fundamental principles of communication engineering.

Radar

Evaluation of C-Band (5.5 cm) Airborne Weather Radar. Henry T. Harrison, Edgar A. Post, George W. Henderson, Donald Smith, Melvin E. Balzer, and Frank Todd. *United Air Lines Rep.*, Mar. 1, 1954. 108 pp. 13 refs.

A Method of Making a Radar Self-Calibrating. E. A. Wolff. *Proc. IRE*, Oct., 1954, p. 1521. Design and construction of an experimental airborne system to measure readily the radar input-output characteristic and the over-all system performance.

PPI Light Spot Brightness Probability Distributions. George C. Sponsler and Fern L. Shader. *J. Appl. Phys.*, Oct., 1954, p. 1271. USAF-Army-Navy-supported study at MIT of the radar detection problem, taking into account the factors of highlight brightness versus the intensifier electrode voltage transfer characteristic.

Radar Offers Solution to Midair Plane Collisions. James Q. Brantley. *Electronics*, Nov., 1954, p. 146. Cornell Aero. Lab.-sponsored development of the continuous-wave Doppler technique to provide an automatic evaluation of collision potential by the measurement of the closure rate and the deviation of closure rate and closure angle.

Radar-Vision for Transports. James P. Holahan. *Skyways*, Oct., 1954, p. 16. Developmental study of design, operational, and other characteristics of the AN/APS-42 radar set.

Semiconductors

Diode Amplifier; Semiconductor Amplifier Offers Important Applications in Computers and Other Electronic Devices. *U.S., NBS Tech. News Bul.*, Oct., 1954, p. 145. Design, operational, and other characteristic factors of the NBS-developed device.

The Effect of a Transverse Electric Field on Carrier Diffusion in the Base Region of a Transistor. J. S. S. Kerr, J. S. Schaffner, and J. J. Suran. *J. Appl. Phys.*, Oct., 1954, p. 1293. Study of the performance characteristics of semiconductor devices dependent on the flow of electrons and holes inside the semiconducting materials.

Feedback Simplifies Transistor Amplifiers. Stanley Schenkerman. *Electronics*, Nov., 1954, p. 129. Use of degenerative feedback path shunting the output in series with the input, without the need for interstage transformers or grounded-collector stages, to obtain voltage amplification in transistor stages.

IRE Standards on Electron Devices: Definitions of Semiconductor Terms, 1954. E. Weber, W. J. Dodds, G. D. O'Neill, R. S. Burnap, R. M. Ryder, J. P. Jordan, A. E. Anderson, S. J. Angello, and others. *Proc. IRE*, Oct., 1954, p. 1505.

Telemetry

Pulse Transmitter for Rocket Research. D. G. Mazur. *Electronics*, Nov., 1954, p. 164. Design and development of the 15-channel AN/DKT-7 airborne telemeter for use in the Aerobee; circuit details, performance characteristics, and in-flight calibration procedure.

Transmission Lines

Analysis of Transmission Line Directional Couplers. W. L. Firestone. *Proc. IRE*, Oct., 1954, p. 1529. 14 refs. Derivation of expressions for the directivity and coupling, with and without reflections being present, for six different types of transmission lines.

Calculating the Impedance of Co-Axial Lines. E. B. Herman. *Tele-Tech*, Nov., 1954, p. 92. Determination from the known constants of the separate layers of the characteristic impedance of lines fully or partially loaded with various dielectrics.

Electromagnetic Wave Propagation in Bounded Electron Beams. Philip Parzen. *Quart. Appl. Math.*, Oct., 1954, p. 309. Analysis for the case where the current density is parallel to the electron velocity to determine the modes of propagation in a right cylindrical waveguide completely filled with an electron beam with an arbitrary longitudinal time independent velocity.

Step Discontinuities in Disk Transmission Lines. R. N. Bracewell. *Proc. IRE*, Oct., 1954, p. 1543.

Equipment

Trends in Aircraft Test Equipment. Julius Kendall. *Aero Dig.*, Oct., 1954, p. 53. Appraisal of the factors of relability, correlation, and repeatability in the essential requirements of accessory testing.

Electric

Aircraft Electrical Systems: Cooling Techniques for Airborne Equipment. Cecil Martin. *Aero Dig.*, Oct., 1954, p. 33.

Automatic Paralleling of Aircraft A-C Generators. M. J. Powell and E. W. Giloy. *Elec. Eng.*, Nov., 1954, p. 1028. Abridged. Analysis of design and related criteria.

Design of New Electrical Power Systems. C. K. McBaine. *Aero Dig.*, Oct., 1954, p. 38. Development of methods to obtain reliable estimates of the weight of projected circuits and equipment.

Developments in Aircraft Electrical Power. G. A. Phillips. *Aero Dig.*, Oct., 1954, p. 26. Survey of trends toward new design principles as means of meeting increased power needs and to solve distribution and cooling problems.

Electric Controls. V—Adjustable-Speed Drives. John C. Ponstingl. *Tool Engr.*, Nov., 1954, p. 89. Appraisal of the relative merits of electrical drives for various applications.

Thermal Considerations in Electrical Accessory Design. Appendix—Data Required for Accurate Engineering Evaluation of Electrical Accessory Cooling Requirements. E. W. Cornwall. *Aero. Eng. Rev.*, Dec., 1954, p. 59. Appraisal of design and operational requirements related to reliability and efficiency factors of equipment cooling, taking into account the basic elements of size, power consumption, and weight.

Hydraulic & Pneumatic

Clearance Design in Hydraulic Pumps and Motors. Warren E. Wilson. *Mach. Des.*, Oct., 1954, p. 249. Theoretical principles applied to determine optimum clearances, taking into account the variation in viscosity occurring with heat generation in the slip passages of positive-displacement units.

Hydraulic Accessory Drives. Carl L. Sadler. *Aero Dig.*, Oct., 1954, p. 46. Analysis of operational and applicational requirements to obtain constant speed power sources for generating equipment.

Potential Advantages of the 5000 psi Pneumatic System. A. E. Schmidlin. *Appl. Hydraulics*, Oct., 1954, p. 118.

Progress in Hydraulic Design Engineering. George McLaughlin. *Aero Dig.*, Oct., 1954, p. 42. Appraisal of requirements to increase power, reduce weight, and improve performance.

Flight Operating Problems

Cruise Control & Piloting

Flying Techniques with the Research Airplanes. A. Scott Crossfield. *CAI Log*, Nov., 1954, p. 23. Appraisal of the role of the pilot and piloting of an experimental aircraft, taking into account the elements of increased complexity of controls, many new and unknown operational factors, and the need for objective and reliable interpretation and presentation of flight data.

Fuels & Lubricants

Liquid Fuels for Turbojets and Turbines. J. Bennett Hill, and others. *Ind. & Eng. Chem.*, Oct., 1954, p. 2149. 67 refs. Contents: Effect of Molecular Structure on Combustion Behavior, L. C. Gibbons, Henry C. Barnett, and Melvin Gerstein. Aircraft Turbine Fuel Properties Affecting Combustor Carbon, D. P. Barnard and Lamont Eltinge. Corrosion and Deposit in Gas Turbines, B. O. Buckland. Stability of Aircraft Turbine

Fuels, C. R. Johnson, D. F. Fink, and A. C. Nixon.

Mixed Friction Conditions in Lubrication. D. D. Fuller. *Lubrication Eng.*, Sept.-Oct., 1954, p. 256. 11 refs.

Relation Between Net Heat of Combustion and Aniline-Gravity Product of Aircraft Fuels. Ralph S. Gessup and Joseph A. Cogliano. *ASTM Bul.*, Oct., 1954, p. 55. 18 refs. NavBuAer-sponsored experimental investigation at NBS utilizing 36 samples of AN-F-28, AN-F-58, JP-4, and JP-5 fuels.

Synthetic Aircraft Greases. H. Schwenker, J. A. King, and J. C. Mosteller. *Lubrication Eng.*, Sept.-Oct., 1954, p. 266. USAF-development of greases to meet operational requirements of the −65°–450°F. temperature range.

Gliders

The Low-Drag Sailplane. August Raspet and Raymon Parker. *Soaring*, Nov.-Dec., 1954, p. 10. Aerodynamic analysis of the design feature of geometric boundary layer control in the 1954 Tiny Mite Modification.

The Value of Gliding and Soaring for Training Airline and Military Pilots. L. A. de Lange. *Soaring*, Nov.-Dec., 1954, p. 13.

Ice Formation & Prevention

"Araldite" in the Napier Surface Heater De-Icing Equipment. *Aero Res. TN Bul. 140*, Aug., 1954, p. 1. Specialized use of the epoxy resins in anti-icing and de-icing mats heated electrically, with an appraisal of relative merits, technical and maintenance requirements, and other factors.

Instruments

Automatic Control

Calcul Semi-Théorique d'un Servo-Mécanisme de Position. R. Moreau. *La Recherche Aéronautique*, July-Aug. 1954, p. 27. In French. Semi-theoretical method to calculate the optimum requirements of a servomechanism to a particular problem.

The "Least Squares" Criterion Applied to Linear Servos. R. Voles. *Electronic Eng.*, Oct., 1954, p. 452.

Time-Scale and Gain Influence on Servo Performance. Dunstan Graham and R. C. Lathrop. *Elec. Eng.*, Nov., 1954, p. 995. Abridged.

Flight Instruments

A Method of Calibrating Airspeed Installations of Airplanes at Transonic and Supersonic Speeds by the Use of Accelerometer and Attitude-Angle Measurements. John A. Zalovcik, Lindsay J. Lina, and James P. Trant, Jr. (*U.S., NACA TN 2099*, 2570, 1950, 1952.) *U.S., NACA Rep. 1145*, 1953. 13 pp. Supt. of Doc., Wash. $0.20.

Flow Measuring Devices

Corrections in Hot-Wire Correlation Measurements. Carl E. Pearson. *Quart. Appl. Math.*, Oct., 1954, p. 235.

The Measurement of the Velocity of a Gas Flow with the Hot-Wire Anemometer. Ulrich Jacob. (*Arch. für Tech. Messen* [Munich], Nos. 216, 217, Jan., Feb., 1954.) *Gt. Brit., RAE Lib. Trans. 476*, July, 1954. (Also in *Gt. Brit., MOS TIB/T4370*, Aug., 1954. Translation of Part II.) 14 pp. 24 refs. Design and operational characteristics; means of improving sensitivity of the measurements; applications of the technique to turbulence measurements.

The Use of Primary Elements in Measurement of Flow. II. Henry W. Stoll. *Taylor Tech.*, Summer-Fall, 1954, p. 19. Review of fundamental principles; application of various techniques based on four designs of orifice plates to specific metering conditions.

Pressure Measuring Devices

An Instrument for Leak Detection and Pressure Measurement in High Vacuum Systems. Edouard G. Leger. *Can. J. Tech.*, Nov., 1954, p. 199. Application to the study of cool flames; design and fabricational factors, with circuit details.

Stress & Strain Measuring Devices

Stabilité en Fonction de la Température des Ponts d'Extensométres à Fil Résistant, Fixés au Moyen de Colles Thermoplastiques. Gérard Faure. *La Recherche Aéronautique*, July-Aug., 1954, p. 33. In French. Experimental development of a method to minimize the deviation of temperature of the resistant wire bridge of an extensometer fixed with the aid of thermoplastic glue.

Strain Gages; Operation, Techniques, and Theory. I. John Tarbox. *CEC Recordings*, Sept.-Oct., 1954, p. 5. Appraisal of basic principles, environmental factors, and applications.

Temperature-Compensated Strain Gages. Alvin B. Kaufman. *Radio-Electronic Eng.*, Nov., 1954, p. 20. Analysis of basic principles and of the effect of Baldwin-Lima-Hamilton gages upon prevailing circuitry as used on annealed mild steel and 24S-T6 duraluminum.

Machine Elements

Bearings

Engine Bearing Design Today. J. B. Bidwell. *Lubrication Eng.*, Sept.-Oct., 1954, p. 272. Analysis of operational requirements and other factors of basic problems.

Frictional Experiments on Lightly-Loaded Fully Floating Journal Bearings. C. F. Kettleborough. *Australian J. Appl. Sci.*, Sept., 1954, p. 211. Interim report on the frictional behavior of different bushes operating with various clearance ratios.

Measured Oil Film Pressure Distribution in Misalined Plain Bearings. F. W. Ocvirk. *Lubrication Eng.*, Sept.-Oct., 1954, p. 262. Results of an NACA-sponsored investigation at Cornell U. to study bearing design and operational problems.

The Mechanism of Rolling Friction. D. Tabor. *Philos. Mag. (7th Ser.)*, Oct., 1954, p. 1081. 10 refs. Application of experimental findings to the operational conditions of ball bearings.

Gears & Cams

Planning Machine Series. IV. Paolo Tedeschi. *Mach. Des.*, Oct., 1954, p. 273. Graphical analysis of the operating characteristics of gear-reducer series, with emphasis on the herringbone type.

Mechanisms & Linkages

Systematic Mechanism Design. II—How to Apply New Symbolic Notation + Catalog of Basic Mechanisms to the Design of a Mechanism for a Specific Function. J. Denavit and R. S. Hartenberg. *Mach. Des.*, Oct., 1954, p. 257.

Rotating Discs & Shafts

Flexible Shafts for Remote Control. W. J. Kupfrian. *Mach. Des.*, Oct., 1954, p. 164. Design of shaft characteristics, operating conditions, and applications to control systems.

Thickness-Shear and Flexural Vibrations of a Circular Disk. R. D. Mindlin and H. Deresiewicz. *J. Appl. Phys.*, Oct., 1954, p. 1329.

Torsion of a Shaft with a Toroidal Cavity. G. Weiss and L. E. Payne. *J. Appl. Phys.*, Oct., 1954, p. 1321. 13 refs. USAF-supported investigation of the basic problem of an n dimensional axially symmetric body in a uniform stream of a nonviscous, incompressible fluid flowing parallel to the axis of symmetry of the body.

Materials

Materials of Construction for Chemical Engineering. *Ind. & Eng. Chem.*, Oct., 1954, p. 2041. 1799 refs. 107-page comprehensive review of the literature broken down by types of materials. Contents: Aluminum Alloys, Harry W. Fritts. Cements, C. R. Payne. Ceramics, Lane Mitchell. Copper and Copper Alloys, Raphael Katzen. Elastomers, Harry L. Fisher. Iron, Mild Steels, and Low-Alloy Steels, Homer L. Shaw. Fibers, Joseph L. Vodonik, Robert S. Casey, and C. S. Grove, Jr. Lead and Lead Alloys, Kempton H. Roll. Nickel and High-Nickel Alloys, H. O. Teeple. Paints, Francis Scofield. Rubber, Hard, Henry Peters. Steels, Stainless, and Other Ferrous Alloys, W. A. Luce. Tin and Its Alloys, Robert J. Nekervis. Wood, Roy H. Baechler and A. J. Stamm. Less Common Metals, Wilfred R. Bekebrede and L. F. Yntema. Plastics, Raymond B. Seymour.

Ceramics & Ceramals

New Trends in Ceramics. Edward E. Mueller and James I. Mueller. *Trend in Eng.*, Oct., 1954, p. 5. 28 refs. Review of developmental factors and characteristic properties; applications include protective coatings of aircraft skins against high temperatures.

Corrosion & Protective Coatings

Motion Pictures as Corrosion Research Aid. F. H. Beck and M. G. Fontana. *Ohio State U. Eng. Exp. Sta. News*, Nov., 1954, p. 3. 83 refs. Includes a comprehensive bibliography covering corrosion problems, experimental techniques, design factors, and applications.

AIRSURANCE
Airline Passenger Insurance

Annual Policies from $5,000 to $100,000 at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $27.50 per year

Policies cover passengers on scheduled airlines WORLD-WIDE

Write or phone your Insurance Agent

U.S.GROUP

Backed by the Combined Assets of
Aetna Casualty & Surety Co
American Employers' Insurance Co.
American Surety Co. of N Y
Century Indemnity Company
The Employers' Liability Assurance Corp., Ltd
Hartford Accident & Indemnity Co.
Maryland Casualty Co
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co
Standard Accident Insurance Co
Travelers Insurance Co
United States Casualty Co
United States Fidelity & Guaranty Co.

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 38, N. Y.
ATLANTA • CHICAGO • DALLAS • KANSAS CITY
LOS ANGELES • SAN FRANCISCO

Consult your

1954 AERONAUTICAL ENGINEERING CATALOG...

for suppliers of aircraft parts, materials, and services

- A master file of company product catalogs.
- 45,000 listings to vendors of over 2,500 aircraft and guided missile materials and components.
- Names, current addresses and general description of products of all principal manufacturers.
- Handy inquiry postcards.

AN OFFICIAL PUBLICATION:

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 E. 64th St. New York 21, N.Y.

Protective Coatings—First Line of Defense Against Corrosion. Paul O. Blackmore. *Interchem. Rev.*, Autumn, 1954, p. 75. Appraisal of the characteristic behavior of corrosion and preventative methods.

Metals & Alloys

Fabricating Characteristics of Stainless Steels. Richard E. Paret. *Prod. Eng.*, Oct., 1954, p. 196. Study of three basic types, the martensitic, ferritic, and austenitic; relation of processes to mechanical properties.

Metals & Alloys, Nonferrous

An Experimental and Theoretical Investigation of the Anistropy of 3S Aluminum-Alloy Sheet in the Plastic Range. Appendix A—Determination of Preferred Orientation; Pole Figures. Appendix B—Method of Computation of Poisson's Ratio in Plastic Ranges; Single Crystals. Arthur J. McEvily, Jr., and Philip J. Hughes. *U. S., NACA TN 3248*, Oct., 1954. 45 pp. 12 refs.

Investigations on the Deep Drawing of Aluminium and Its Alloys. Kamal Abdel Aziz. (*Promotionsarb* [Zurich], No. 2130, 1952.) *Gt. Brit., MOS TIB/T4292*, June, 1954. 105 pp. 26 refs. Translation.

Nonmetallic Materials

The Dynamic Bulk Viscosity of Polyisobutylene. Robert S. Marvin, R. Aldrich, and H. S. Sack. *J. Appl. Phys.*, Oct., 1954, p. 1213. ONR-supported research at Cornell U. and NBS.

Effect of Crystallinity on the Dynamic Mechanical Properties of Polyethylenes. Lawrence E. Nielsen. *J. Appl. Phys.*, Oct., 1954, p. 1209.

Effects of Multiaxial Stretching on Crazing and Other Properties of Transparent Plastics. Irvin Wolock and Desmond A. George. *U.S., NACA RM 54F22*, Oct. 20, 1954. 34 pp.

Fluorocarbon Plastics Today; Fluorocarbon Plastics Tomorrow. Henry Lee and J. A. Jupa. *Prod. Eng.*, Oct., 1954, p. 168. Developmental and comparative review of physical, mechanical, and electrical properties of basic types; potentialities and applications.

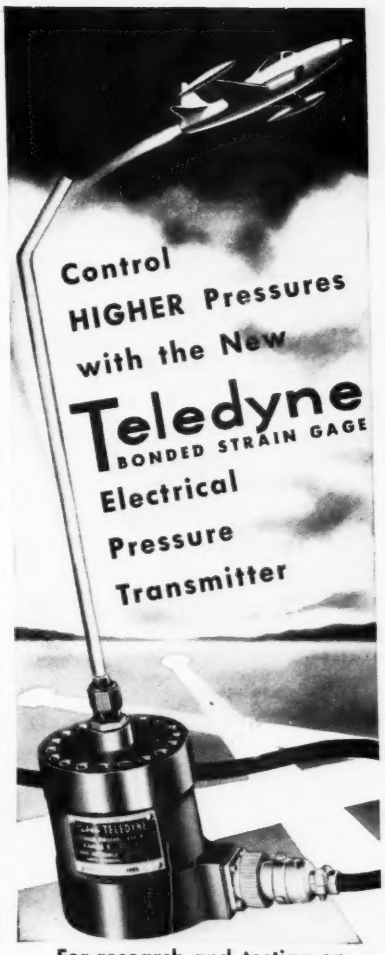
Evaluation of Diene-Type Elastomers; Oil and Solvent Resistance and Low Temperature Flexibility. M. Feldon, D. R. Hammel, and R. W. Laundrie. *Ind. & Eng. Chem.*, Oct., 1954, p. 2248. 13 refs.

Rubber Springs. E. F. Göbel. (*Konstruktionbucher* [Berlin], July, 1945.) *Gt. Brit., MOS TIB/T4187*, July, 1954. 72 pp. 50 refs. Translation. Experimental analysis of the basic properties of rubber under various types of stress conditions; design requirements and applications.

Testing

The Effect of Torsional Overstrain Upon the Static Strength of Spring Steel. J. E. Andrew and J. A. Pope. *Chartered Mech. Engr.*, Oct., 1954, p. 388. Abridged.

Isledovanie Reologicheskikh Svoistv Dispersnykh Sistem (Investigation of Rheological Properties of Dispersed Systems). M. P. Volarovich. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 171. 105 refs. In Russian, with summaries in



For research and testing on rockets, pulse jets, and turbo jets. 15 ranges, 0-10,000 P.S.I.

Now, those engaged in research and testing of rockets, pulse jets and turbo jets can measure, record and control high pressures using a TELEDYNE electrical pressure transmitter that is both ACCURATE and DURABLE. These features make the new Teledyne the most advanced piece of equipment of its kind available: 15 ranges (0-10,000 PSI) for wide application. Bonded strain gage construction (insensitive to vibration or shock). High frequency response. Linear output over full pressure range. Easily disassembled for clean out and repairs. Insensitive to accelerations in 2 horizontal planes and vertically less than .3% of full scale per "G". Temperature compensated for zero shift and sensitivity change.

CLIP THIS COUPON TO YOUR LETTERHEAD FOR LITERATURE

Taber INSTRUMENT CORPORATION
111 Goundry St., N. Tonawanda, N. Y.
SECTION 40

Please send me illustrated literature on your new TELEDYNE.

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... STATE .....

DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Polish and English. Review of Russian developments in the study of easily deformable materials, with an analytical interpretation of viscoplastic flow; appraisal of test methods; applications of the experimental results.

Z Zagadnień Teorii Elementów Uzwojonych w Świetle Reologicznych Właśności Materiałów (Sur la Théorie des Éléments Frettés Compte Tenu des Propriétés Rhéologiques des Matériaux). Wacław Olszak. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 203. 27 refs. In Polish, with summaries in French and Russian. Extension of theoretical rheological investigations into the characteristics of iron-banded elements for the special case of an isotropic core with elastic linearity, taking into account the boundary limits due to the flow of the core.

Mathematics

Applications of the Dirac Delta Function to the Evaluation of Certain Integrals. Murray R. Spiegel. *J. Appl. Phys.*, Oct., 1954, p. 1302.

Errors in Asymptotic Solutions of Linear Ordinary Differential Equations. Robert L. Evans. *Quart. Appl. Math.*, Oct., 1954, p. 295.

Method of Averages and Its Comparison with the Method of Least Squares. Morris Morduchow. *J. Appl. Phys.*, Oct., 1954, p. 1260.

Operational Mathematics. Ruel V. Churchill. *Appl. Mech. Rev.*, Nov., 1954, p. 469. Basic properties in the theory and application of linear integral transformations in connection with the solution of boundary-value problems in differential equations.

Zur Lösung Potentialaufgaben mit Hilfe des Differenzenverfahrens. Johann Schröder. *ZAMM*, July, 1954, p. 241. In German. Simplified difference method to solve boundary problems of the two- and three-dimensional potential theory.

Meteorology

The Applicability of Continuous-Fluid Theory in the Higher Atmosphere. Donald G. Yerg. *J. Meteorology*, Oct., 1954, p. 387. USAF-sponsored investigation at The Penna. State U., with potential use of results in the formulation of problems concerned with the kinetic theory and dynamics of the F region.

Corrections of Upper-Level Wind Computations for Effect of Earth's Curvature. LeRoy H. Clem, DeVer Colson, and Louis P. Harrison. *Bul. AMS*, Oct., 1954, p. 357. Development of methods to permit more accurate upper-air analyses and navigation under jet-stream conditions.

The Development of the Size Distribution of Raindrops During Their Fall. E. C. Rigby, J. S. Marshall, and Walter Hitschfeld. *J. Meteorology*, Oct., 1954, p. 362. 15 refs. USAF-sponsored theoretical study to interpret radar echoes and to formulate a mechanism of precipitation taking into account collisions among drops, the effect of cloud accretion, and evaporation factors.

Meteorological Problems in Forecasting Mountain Waves. DeVer Colson. *Bul. AMS*, Oct., 1954, p. 363. Analysis of the standing-wave phenomenon as a hazard to certain aircraft operations.

On the Analysis of 500-Millibar Zonal Wind Profiles and Index Cycles. F. A. Berry, W. H. Haggard, and P. M. Wolff. *J. Meteorology*, Oct., 1954, p. 380. NavBuAer investigation as part of Project AROWA to develop a technique for conducting the index-cycle analysis.

On the Influence of Waterdrops in the Air upon the Atmospheric Radio-refractive Index. K. Naito. *Papers in Meteorology & Geophys.*, Dec., 1953, p. 109.

On the Wind Speed Profiles in the Lower Atmosphere. M. Tohsha. *Papers in Meteorology & Geophys.*, Dec., 1953, p. 104.

Military Aviation & Armament

Fourth Annual Review of Canada's Air Defences. *Aircraft* (Canada), Oct., 1954, p. 37. 56-page survey of developments covering aircraft, training of personnel, special research, equipment, and other factors.

Missiles

The Drag of Non-Planar Thickness Distributions in Supersonic Flow. Appendix I—Optimum Thickness Distribution for Elliptical Planform. Appendix II—Ring-Wing and Central Body of Revolution Combination Having Drag of Sears-Haach Body; Ring-Wing and Central Body of Revolution Having Zero Drag. E. W. Graham, B. J. Beane, and R. M. Licher. *Douglas Rep. SM-18280*, May, 1954. 24 pp.

Special Engineering and Development Issue: Missiles. *Am. Av.*, Oct. 25, 1954. 154 pp. Partial contents: The Role of the Missile. America's Missile Arsenal. Missiles and the Aircraft Industry. Technology: I—Powerplants; II—Electronics; III—Structures; IV—Guidance. Missiles of the NATO Nations. Missiles for Research. Tracking the Missile. Industry Looks at Missile Problems. Missile Product Inventory.

The Zero-Lift Drag of a Slender Body of Revolution (NACA RM-10 Research Model) as Determined from Tests in Several Wind Tunnels and in Flight at Supersonic Speeds. Albert J. Evans. (*U. S., NACA TN 2944*, 1953.) *U. S., NACA Rep. 1160*, 1954. 13 pp. Supt. of Doc., Wash. $0.20.

Noise Reduction

Noise Measurements. Adam Currie and Craig Walsh. *Elec. Mfg.*, Nov., 1954, p. 76. Review of techniques to study the fundamental factors; development of a test code for rating noise generation.

Photography

A Forward Angle Light Scattering Camera for Determining Size Distribution in Aerosols. Pui-Kum Lee and Victor K. La Mer. *Rev. Sci. Instr.*, Oct., 1954, p. 1044. 20 refs. USAF-supported design and development.

Graphische Lösung der Hauptaufgabe der Luftphotogrammetrie im Sinne der Ausgleichsrechnung. Josef Krames. *ZAMM*, July, 1954, p. 254. Deduction of a simple graphic method based on the geometrical theory of "critical" ground services for the restitution of the relative position of two aerial photographs taken from two different centers.

Photographic Motion Analysis. XVIII. John H. Waddell and Jennie W. Waddell. *Ind. Labs.*, Nov., 1954, p. 101. Review of tools and techniques, with applications including: the flight measurement of low-level missiles; aeroballistics; detonation, explosion, and time-lapse studies; and experimentation with vibration problems.

Selected Projects of the Aerial Reconnaissance Laboratory, Wright-Patterson Air Development Center. Eldon D. Sewell. *Photogrammetric Eng.*, Sept., 1954, p. 689.

Power Plants

Jet & Turbine

Gas Turbines of the USA. Peter Berry. *Aeronautics*, Oct., 1954, p. 62. A comprehensive developmental survey of turbojet and turboprop engines outlining progress from 1941.

Miles' First Jet Racer. *The Aeroplane*, Oct. 1, 1954, p. 512, cutaway drawings. Structural design, performance, and other characteristics of the M.77 Sparrowjet.

The Napier Nomad, a Diesel Compounded with Compressor Plus Turbine for Aircraft Use. Herbert Sammons and Ernest Chatterton. (*SAE Summer Meeting, Atlantic City, N. J., June 10, 1954, Paper.*) *SAE J.*, Oct., 1954, p. 62. Abridged.

Two Spool Aircraft Engines. John Mitchell Stephenson. *Aero Dig.*, Nov., 1954, p. 58. Review of jet design problems, including factors of propulsive efficiency, thrust conversion, compressor-pressure ratio, controls, and operational critieria.

Thrust Augmentation. G. C. R. Mathieson. *The Aeroplane*, Oct. 1, 1954, p. 516. A detailed analysis of methods.

Formation et Depot de Carbone Dans Les Foyers de Turbo-Machines D'Aviation. C. Fouré. *NATO AGARD Memo. AG12/M8*, 1954. 22 pp. 13 refs. In French. Study of the problem of the formation and deposition of carbon in combustion chambers of aircraft turbomachines, and of the related factors, with detailed charts and diagrams.

Some Aspects of Combustion of Liquid Fuel. Charles C. Graves and Melvin Gerstein. *NATO AGARD Memo. AG16/M10*, 1954. 27 pp. 25 refs. Analysis of experimental studies on diffusion flames with emphasis on such processes as fuel spray spreading and evaporation and efficiency of combustion of liquid fuels in turbojet combustors as affected by fuel volatility, spray characteristics, and the burning rate of single drops.

Transverse Oscillations in a Cylindrical Combustion Chamber. Franklin K. Moore and Stephen H. Maslen. *U.S., NACA TN 3152*, Oct., 1954. 25 pp. Investigation of the transverse resonance characteristics in an idealized jet combustion chamber, taking into account the effect of axial gradient of mean temperature,

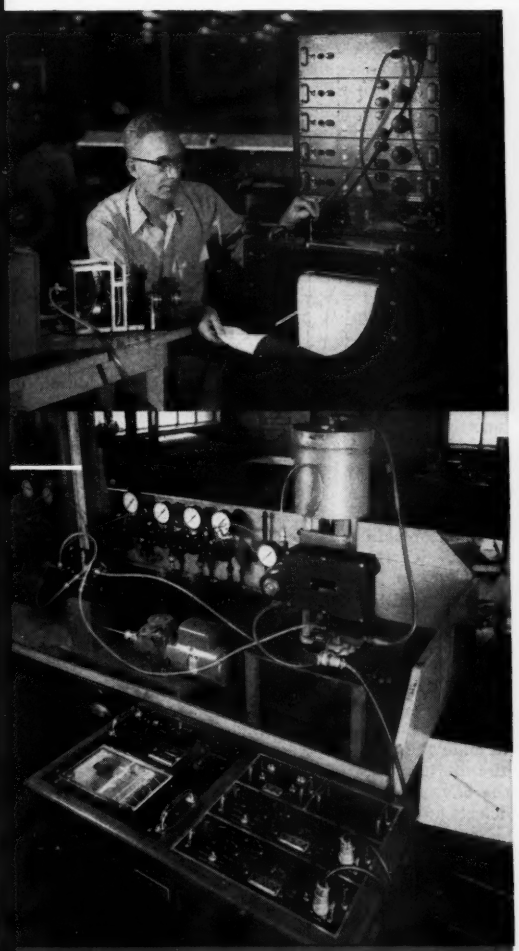
How two TYPICAL production testing headaches were cured with SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS

RAYTHEON MANUFACTURING COMPANY'S Waltham, Mass. Inspection Dept. formerly found their incoming inspection of complex, multi-ganged potentiometers a time-taking and costly job which involved tedious calibration, instrument set-up and testing for *each* of the five potentiometer sections, with each operation subject to inevitable human error.

Today, by using a Sanborn four-channel Recording System and a Potentiometer Power Supply, a visual, concurrent strip-chart record of *five* channels (using marker stylus) of phenomena such as phasing, shorting bar, winding noise, and resolution of winding turns is provided. Inspection time is speeded up 900%, the operator sees immediately all causes for rejection, the chart is a permanent test data record, one inspector takes the place of three, and human error is reduced to a negligible factor.

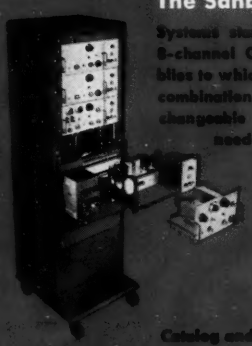
MOORE PRODUCTS COMPANY of Philadelphia uses a Sanborn Model 60 two-channel Recording System to check the Dynamic Performance of their Valve Positioners, which are used on diaphragm top-work valves and power cylinders. The valve positioner acts as a relay, applying additional air pressure to the cylinder or top-work, overcoming effects of unbalance and friction, and compelling the valve stem to take the position dictated by the pneumatic controller or manually-operated air load. A feed-back linkage assures positioning of the valve stem within plus or minus 0.001".

A pneumatic sine wave generator supplies pneumatic impulses with frequencies as high as 20 cycles per second. These impulses are sent to the valve positioner and to a transducer which converts the signal for the recorder. The response of the valve stem is measured by a strain gage pickup for the second channel of the recorder.



The above cases are but two of the many applications possible with Sanborn one-, two-, four-, six- and eight-channel Recording Systems. With a Sanborn you can register permanently and graphically virtually all electrical phenomena within a frequency range of zero to 100 cps. A choice of the number of channels, plus the ready interchangeability of various type preamplifiers (to meet individual recording problems) offers a wider versatility of use, greater overall economy, and increased operating efficiency.

Added to these advantages are the standard SANBORN instrument features: INKLESS recording in true rectangular coordinates, high torque galvanometer movement, time and code marking, and numerous paper travel speeds.



The Sanborn "150" Series

Systems start with 1-, 2-, 4-, 6- or 8-channel Cabinet-Recorder Assemblies to which the user adds whatever combination of the following interchangeable plug-in Preamplifiers is needed for his work.

- **AC-DC**
- **Carrier**
- **Servo Monitor**
- **DC Coupling**
- **Log-Audio**
- **Low Level Chopper**
- **Input Network**

Catalog and Technical Data on "150" Equipment available on request.

SANBORN COMPANY
INDUSTRIAL DIVISION
CAMBRIDGE 39, MASSACHUSETTS

with an analysis of flame-holder wake idealized as a thin annulus performing mechanical work on the surrounding gases.

Vaporization Rates and Drag Coefficients for Isoctane Sprays in Turbulent Air Streams. Robert D. Ingebo. *U.S., NACA TN 3265*, Oct., 1954. 39 pp. 14 refs. Use of heat-transfer equations in the analysis of the basic problem, with solutions applied to the fuel injector systems of jet engines.

Reciprocating

Radioactive Isotopes for Measuring Piston Ring Wear. J. H. Deterding and A. Dyson. *The Engr.*, Oct. 1, 1954, p. 442. Development of a test method to investigate wear of cylindrical bores and rings of internal combustion engines over short intervals of running time.

Production

Metalworking

Contribution à l'Étude Tensiométrique du Collage des Métaux. Henri L. Rosano and G. Diehl. *La Recherche Aéronautique*, July-Aug., 1954, p. 41. In French. Review of three investigations in metal-to-metal bonding techniques; use of the tensiometric method to study the treatment of surfaces of metals in terms of adhesive requirements and of relative values and strengths.

Welding

Flash Welding High Strength Alloy Steels. W. G. Fassnacht. *Welding J.*, Oct., 1954, p. 937. Review of the current practice used to fabricate aircraft landing gear.

Metallurgical Aspects of Welding Precipitation-Hardening Stainless Steels. C. W. Funk and M. J. Granger. *Welding J. Res. Suppl.*, Oct., 1954, p. 496-s. 13 refs. Investigation at Aerojet-General to determine the response of welded joints of aircraft materials to heat treatment and the effects of such treatments and weld defects on mechanical properties.

Spot Welding Aluminum with Single Phase Equipment. J. W. Kehoe and D. R. McCutcheon. *Welding J.*, Oct., 1954, p. 966. Development of a schedule for use on four widely used aluminum alloys in 257 different combinations with only eight closely related machine settings.

The Fusion Welding of Aluminium Alloys. I—A Survey of Published Information on the Fusion Welding of Heat-Treatable Aluminium Alloys. H. E. Dixon. **II—Review of Published Information on Weld Cracking in Aluminium Alloys, with Particular Reference to Al-Mg-Si Alloys.** W. G. Hull and D. Adams. **III—Dilution and Uniformity in Aluminium Alloy Weld Beads.** P. T. Houldcroft. *Brit. Welding J.*, Oct., 1954, p. 455. 47 refs.

Reference Works

The Department of Aeronautical Engineering and the Aircraft Industry. Frank McL. Mallett. *Ohio State U. Eng. Exp. Sta. News*, Nov., 1954, p. 8. 26 refs. Survey of research investigations, with a listing of masters' theses.

IRE Standards on Electron Devices: Definitions of Semiconductor Terms, 1954. E. Weber, W. J. Dodds, G. D. O'Neill, R. S. Burnap, R. M. Ryder, J. P. Jordan, A. E. Anderson, S. J. Angello, and others. *Proc. IRE*, Oct., 1954, p. 1505.

Isledovanie Reologicheskikh Svoistv Dispersnykh Sistem (Investigation of Rheological Properties of Dispersed Systems). M. P. Volarovich. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 171. 105 refs. In Russian, with summaries in Polish and English. Review of Russian developments in the study of easily deformable materials, with an analytical interpretation of viscoplastic flow; appraisal of test methods; applications of the experimental results.

List of Reports, Second Edition; Corrections and Supplement 1954. *Netherlands NLL Rep.*, July, 1954. 78 pp. 781 refs. Author and subject bibliography with breakdowns on: general aerodynamics; flutter and theoretical aerodynamics; materials; structures; and flight mechanics.

Materials of Construction for Chemical Engineering. *Ind. & Eng. Chem.*, Oct., 1954, p. 2041. 1799 refs. 107-page comprehensive review of the literature broken down by types of materials. Contents: Aluminum Alloys, Harry W. Fritts. Cements, C. R. Payne. Ceramics, Lane Mitchell. Copper and Copper Alloys, Raphael Katzen. Elastomers, Harry L. Fisher. Iron, Mild Steels, and Low-Alloy Steels, Homer L. Shaw. Fibers, Joseph L. Vodonik, Robert S. Casey, and C. S. Grove, Jr. Lead and Lead Alloys, Kempton H. Roll. Nickel and High-Nickel Alloys, H. O. Teeple. Paints, Francis Scofield. Rubber, Hard, Henry Peters. Steels, Stainless, and Other Ferrous Alloys, W. A. Luce. Tin and Its Alloys, Robert J. Nekervis. Wood, Roy H. Baechler and A. J. Stamm. Less Common Metals, Wilfred R. Bekebrede and L. F. Yntema. Plastics, Raymond B. Seymour.

Motion Pictures as Corrosion Research Aid. F. H. Beck and M. G. Fontana. *Ohio State U. Eng. Exp. Sta. News*, Nov., 1954, p. 3. 83 refs. Includes a comprehensive bibliography covering corrosion problems, experimental techniques, design factors, and applications.

Rotating Wing Aircraft

Design Considerations in the Kaman Servo-Controlled Intermeshing-Rotor Helicopter. Charles H. Kaman. *AHS New England Reg. Meeting, Windsor Locks, Conn., Feb. 9, 1953, Paper.* 6 pp.

The Domain of the Helicopter. (The Seventh Louis Bleriot Lecture, Mar. 10, 1954.) Raoul Hafner. *J. RAeS*, Oct., 1954, p. 661. 33 refs. The 41-page complete English text, being a developmental review of helicopter problems, applications, and future potentialities, including factors of basic design, performance limitations, rotor systems, and civil and military utilization.

Helicopter Control to Trim in Forward Flight. W. Stewart. *Gt. Brit., ARC R&M 2733* (Mar., 1950), 1954. 33 pp. 19 refs. BIS, New York. $2.00. Theoretical estimation of the feathering amplitudes required to trim the complete helicopter, with a comparison of experimental flight values obtained on the Sikorsky R-4B and S-51 types, taking into account the effects of the center of gravity position, fuselage, pitching moment, and other factors.

A Note on the Short-Haul Commercial Transport Helicopter. Edward F. Katzenberger. *AHS Meeting, Washington, D.C., Dec. 21, 1953, Paper.* 21 pp. Appraisal of basic factors and problems of operational cost, noise, vibration, maintenance, component life, stability characteristics, loading provisions, passenger accommodations, and design trends.

Some Notes on Helicopter Power Systems. Raymond A. Young. *AHS Meeting, Los Angeles, Mar. 31, 1954, Paper.* 27 pp. 10 refs.

Safety

The Level of Safety Achieved by Periodic Inspection for Fatigue Cracks. R. R. Shaw. *J. RAeS*, Oct., 1954, p. 720.

Structures

Comparative Efficiency in Bending of Structural Elements of Various Designs and Solidity. George Gerard. *NYU Coll. Eng. Rep.*, Apr., 1952. 86 pp. 29 refs. ONR-sponsored investigation of the relative merits of different constructural methods for aircraft components, including: stiffened panel-rib, multicell, and post-stiffened wing and tail surface elements; stiffened panel-frame and unstiffened cylindrical fuselage elements; and sandwich construction.

Empirical Formulae for the Determination of Stress Curves. A. C. Nicholls. *J. RAeS*, Oct., 1954, p. 724.

O Transformatach Niektórych Równań Rożniczkowych Statyki Budowli (The Transforms of Differential Equations of the Theory of Structures). T. Iwiński and J. Nowiński. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 343. 19 refs. In Polish, with summaries in English and Russian. Analysis of the use of the Laplace transformation method in problems of statics, with illustrative cases of the bending of beams and plates.

Bars & Rods

On the Axially-Symmetric Steady Wave Propagation in Elastic Circular Rods. Julián Adem. *Quart. Appl. Math.*, Oct., 1954, p. 261. Development of an exact solution for the basic general problem, with the elastic bar being of infinite length, free of stress on its lateral surface, and loaded by a harmonic body force parallel to its axis with an amplitude of a Dirac delta function; additional development of a solution for the case of the semi-infinite bar in which the conditions at the boundary plane are prescribed in terms of functions giving implicitly the stresses and displacements.

Beams & Columns

Buckling and Moment Table for Steel Beams. L. P. Hollingsworth. *Prod. Eng.*, Oct., 1954, p. 211.

Dźwigary Zattamane w Planie (Beams Having a Horizontal Projection in the Shape of a Broken Line). Witold Wierz-

bicki. *Rozprawy Inżynierskie* (Warsaw), No. 11, 1954. 69 pp. In Polish, with summaries in English and Russian. Includes an application of the theory of finite differences as a method of calculation to analyze the broken-beam problem as for the case of continuous girders for which twisting moments are deduced.

The Stress Distribution in a Swept-back Box-beam with Perpendicular Ribs. P. B. Hovell. *Gt. Brit., ARC R&M 2837* (Dec., 1950), 1954. 18 pp. BIS, New York. $1.25.

Vibrations of Twisted Beams. R. C. DiPrima and G. H. Handleman. *Quart. Appl. Math.*, Oct., 1954, p. 241. USAF-sponsored investigation at CIT as an extension of the Prager representation of the equations of static equilibrium for curved, twisted beams to include dynamic effects.

Zwichrzenie Sprężyste Belek Prostych w Przypadku Ogólnym (The General Case of Elastic Lateral Buckling of Straight Beams). Marian Piątek. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 235. In Polish, with summaries in English and Russian. Development of a method to determine the critical load producing the lateral buckling, assuming that the cross-section and the load are variable along the beam in an arbitrary manner.

Connections

The Effect of Various Fits on the Fatigue Strength of Pin-Hole Joints. A. Hartman and F. A. Jacobs. *Netherlands, NLL Rep. M. 1946*, Apr., 1954. 27 pp.

Effects of Prestressing on Fatigue Strength of Spot-Welded Stainless Steels. Andre Choquet, V. N. Krivobok, and Georges Welter. *Welding J. Res. Suppl.*, Oct., 1954, p. 509-s. International Nickel-sponsored investigation to develop basic data on the strength of spot-welded joints in structural components.

De Vermoeiingssterkte van Klinkverbindingen en Pengatverbindingen. J. Schijve. *Netherlands, NLL Rep. M. 1952*, May, 1954. 42 pp. 37 refs. In Dutch. Investigation of the fatigue strength of riveted lap joints and pin-hole joints, with a discussion of the relation between stress concentration and strength reduction factors.

Cylinders & Shells

Graphical Method of Designing Thin-Wall Cylinders. I—Cylinder in Torsion. II—Cylinders in Bending. III—Limitations and Accuracy. J. J. Eden. *Prod. Eng.*, Oct., 1954, p. 180.

Statecznośc Rusztu Walcowego (The Stability of a Cylindrical Gridwork System). Janusz Czulak. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 291. In Polish, with summaries in English and Russian. Analysis for the case of a vertical load uniformly distributed over the covering of the system.

Elasticity & Plasticity

Kwantyzacja Zjawisk Niestatecznośći Sprężystej (The Quantization of the Phenomena of Elastic Unstability). II. Jarosław Naleszkiewicz. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 261. 13 refs. In Polish, with summaries in English and Russian. Illustrative analysis of the case of a bar having a uniform cross-section, loaded by an axial force, a torque and a bending moment, on statically determinate supports, under the assumption that for the trivial state of the deformation under critical loading it retains its prismatical shape and for an untrivial state it becomes curved and twisted.

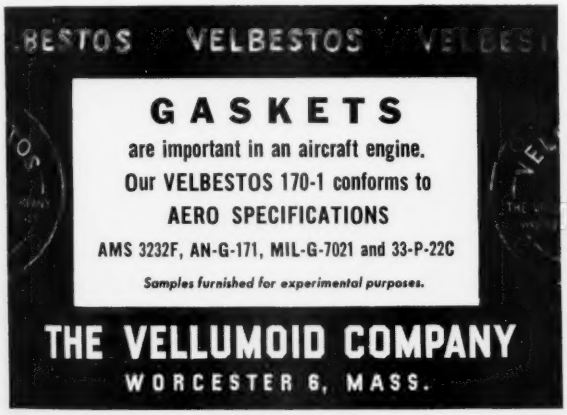
On Inelastic Thermal Stresses in Flight Structures. Alfred M. Freudenthal. *J. Aero. Sci.*, Nov., 1954, p. 772. 10 refs. Analytical investigation of the effect of inelastic behavior of the structural material, with constant and with temperature-dependent parameters; comparison of results with those of elastic analysis in terms of conventional design.

On the Axisymmetric Boundary Value Problems in the Transversely Isotropic Elasticity Theory. Masakazu Higuchi. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, Aug., 1954, p. 143.

Over het Knikvraagstuk in het Plastische Gebied bij Staven en Platen (On the Buckling of Rods and Plates in the Plastic Region). I—Theorie. J. F. Besseling. *Netherlands, NLL Rep. S. 407*, 1952. 94 pp. In Dutch.

Plates

Buckling of a Rectangular Plate under Locally Distributed Forces Applied on the Two Opposite Edges. III. Noboru Yamaki. *Tôhoku U. (Japan) Rep. Inst. High Speed Mech.*, No. 34, 1954, p. 55. Experimental investigation of the stress distribution by means of the Ritz method to obtain the critical value of the load by a determinantal equation.



When you write to manufacturers whose advertising appears in the

Aeronautical Engineering Review,

it will be of interest to the companies and of benefit to the Institute if you mention that you saw it in the

Aeronautical Engineering Review

On a Method of Solving Elastic Problems of Plates. Shôsaburô Negoro. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, Aug., 1954, p. 115.

Stateczność Płyt Prostokątnych Wzmocnionych Żebrami (Stability of Rectangular Plates Reinforced with Stiffening Ribs). Witold Nowacki. *Arch. Mech. Stosowanej* (Warsaw), No. 2, 1954, p. 317. 10 refs. In Polish, with summaries in English and Russian.

Weight Analysis & Control

How a Comparative Weight Analysis of Aircraft Actuators Aids Designers in Choosing the Most Efficient Type. Robert C. Treseder and Howard M. Geyer. *G-M Eng. J.*, Sept.-Oct., 1954, p. 7.

Wings

Over de Sterkteberekening van Pijlvormige Vleugels (On the Stress Analysis of Swept Wings). J. P. Benthem. *Netherlands, NLL Rep. S.405*, 1952. 137 pp. 42 refs. In Dutch. Investigation of the admissibility of the concept of the only shear-carrying oblique panel in discontinuous constructions, taking into account direct stresses in such plates in the case of arbitrary anisotropy; discussion of the existing literature on idealized, continuous cylindrical and conical wing structures.

Thermodynamics

Combustion

Equations for a Hydrogen-Bromine Flame High-Speed Computations. I. Edwin S. Campbell and Thomas F. Schatzki. *U. Wis. NRL Dept. Chem. Rep. CM-819*, Sept. 17, 1954. 81 pp. 16 refs.

Lateral Blowoff of a Bunsen Flame. M. L. Thorp and J. A. Browning. *Ind. & Eng. Chem.*, Oct., 1954, p. 2203. Experimental study of fundamental factors of combustion.

Minimum Spontaneous Ignition Temperatures of Combustible in Air. M. G. Zabetakis, A. L. Furno, and G. W. Jones. *Ind. & Eng. Chem.*, Oct., 1954, p. 2173. 11 refs.

Heat Transfer

Controlling Radiant Heat. R. M. Leedy. *Prod. Eng.*, Oct., 1954, p. 174. 15 refs. Evaluation of basic principles; applications include jet engines and electronic components.

Digital Computer Solution for Heat Transfer to Temperature Probes. H. F. Kraemer and J. W. Westwater. *Ind. & Eng. Chem.*, Oct., 1954, p. 2035.

Heat Flow Through Plastics Materials; a Technique for Solution of Heat Flow Problems. Victor Paschkis. *SPE J.*, Nov., 1954, p. 28. Development of an electrical analogical method taking into account the difficulties of measuring and computing temperatures in the molding and casting processes.

Heat Transfer by Free Convection Across a Closed Cavity Between Vertical Boundaries at Different Temperatures. G. K. Batchelor. *Quart. Appl. Math.*, Oct., 1954, p. 209.

Heat Transfer from Wires to Gases; Maximum Flow Rates in Thermal Conductivity Measurements. A. C. Peterson, A. J. Madden, Jr., and Edgar L. Piret. *Ind. & Eng. Chem.*, Oct., 1954, p. 2038. 10 refs.

Water-Borne Aircraft

The Hydrodynamic Characteristics of an Aspect-Ratio-0.125 Modified Rectangular Flat Plate Operating Near a Free Water Surface. John A. Ramsen and Victor L. Vaughan, Jr. *U.S., NACA TN 3249*, Oct., 1954. 32 pp.

A Proposed Theory to Cover Water Impacts of Seaplanes in which the Craft has Constant Attitude and a Tangetial-to-Keel Velocity Relative to the Water. P. R. Crewe. *Gt. Brit., ARC R&M 2513* (Dec., 1946), 1954. 54 pp. 23 refs. BIS, New York. $3.25.

Wetted Area and Center of Pressure of Planing Surfaces at Very Low Speed Coefficients. Daniel Savitsky and Joseph W. Neidinger. (*Stevens Inst. Tech. ETT Rep. 493*, July, 1954.) *IAS SMF Fund Paper FF-11*, Sept., 1954. 50 pp. 32 refs. Members, $1.20; nonmembers, $1.60. ONR-sponsored experimental tests on 0°, 10°, 20°, and 30° deadrise surfaces in the 0.61—4.00 speed coefficient range to determine hydrodynamic characteristics of planing craft.

Wind Tunnels & Research Facilities

The Department of Aeronautical Engineering and the Aircraft Industry. Frank McL. Mallett. *Ohio State U Eng. Exp. Sta. News*, Nov., 1954, p. 8. 26 refs. Survey of research investigations, with a listing of masters' theses.

Developments in Axial-Flow Compressors. A. I. Ponomareff. *Westinghouse Engr.*, Nov., 1954, p. 218. Basic principles; design and performance characteristics; application to wind-tunnel systems.

A Scheme of Automatic Data Reduction for Wind Tunnels. K. V. Diprose. *NATO AGARD Memo. AG9/M5*, Sept., 1953. 18 pp. RAE development of the design of the computing devices.

The Water Tunnel: Tool in Aerodynamic Research. J. M. Robertson. *Aero Dig.*, Nov., 1954, p. 34. Developmental appraisal of potentialities.

Wind Tunnels—Why and Where. C. A. Scarlott. *J. Franklin Inst.*, Oct., 1954, p. 257. Study of wind tunnel requirements, including design, location, size, development of air speeds, operating conditions, equipment, instrumentation, and functions applied to complex problems.

Keep Posted on New Aircraft Products and Product Literature

Make it a habit to check the *Aeronautical Engineering Review's* "New Products Section" every month. Located at the end of each issue, it contains a complete review of all recently announced new product developments and product literature of special interest to the aeronautical profession. Handy tear-out postals are included for your convenience in requesting additional information direct from the manufacturers.

Make It a Habit—Use the "New Products Section" Every Month

AERONAUTICAL ENGINEERING REVIEW

Aeronautical Reviews — BOOKS

Some Basic Problems of the Mathematical Theory of Elasticity

By N. I. Muskhelishvili. Translated from the Russian by J. R. M. Radok. 3rd Ed. Groningen, Netherlands, P. Noordhoff, Ltd., 1953. 704 pp., illus., diagrs., figs. $10.50.

The recent appearance of this impressive new text brings to the English-speaking public one of the latest outstanding contributions to the theory of elasticity. In this treatise Muskhelishvili presents the most recent advances in the methods of analysis of problems in the field of elasticity which have appeared in the Russian literature. The usefulness of these methods may be observed in the increasing number of papers now appearing in the non-Russian literature which are either utilizing or extending Muskhelishvili's work to their specific applied problems.

The subject matter represents a new and modern viewpoint of the theory of elasticity for problems in the plane or two-dimensional category. The text is divided into seven parts and covers in a very lucid and well-organized concise manner the variety of concepts necessary for the basic understanding of the problems in elasticity.

The first part, subdivided into three chapters, recapitulates the basic concepts of the mathematical theory of elasticity with the development of the complete system of equations of the mechanics of an elastic isotropic body. The development is augmented with the proofs of some of the fundamental propositions associated with the equations. The topics discussed in great detail are: analysis of stress; analysis of strain including transformations, displacements, and compatibility; generalized Hooke's Law; Saint Venant's principle; fundamental boundary-value problems of static elasticity and uniqueness of solution; and dynamic equations of an elastic body.

Part II deals with the general formulas of the plane theory of elasticity, in a manner which has been found very useful for the effective solution of the fundamental boundary-value problems as well as for investigations of a general nature. This part, subdivided into four chapters (4–7), begins with the discussion of the basic equations of the plane theory of elasticity, treating such topics as plane strain, deformation of thin plates under forces acting in its plane, and basic equations with and without the presence of body forces.

The following three chapters represent the effect of the modern viewpoint of the theory of elasticity. Muskhelishvili elaborates in great detail on the definition of the stress function with its limitations and usefulness. This development is followed by the introduction of the complex representation of these biharmonic functions with the corresponding representation of the displacements, stresses, forces, and moments. The use of the complex representation in problems of plane strain and stress leads one to the problem of determining two analytic functions which satisfy both the simply and multiply connected domain, and the uniqueness of the solutions is proved. The final section of the chapter discusses the state of stress on the elastic constants.

Chapter 6 presents in a concise but well-organized manner the theory of multivalued displacements and the associated concept of dislocations. The development then leads to the introduction of thermal stresses.

The concluding phase of Part II is devoted to the fundamentals of conformal mapping and the application of conformal mapping to the transformation of the formulas of the plane theory of elasticity together with the boundary conditions into the image region.

Part III deals with the solution of several problems of the plane theory of elasticity utilizing the power series. Muskhelishvili shows that this method of solution is directly applicable to regions bounded by one or two concentric circles. Thus with the use of conformal transformation, it is possible to extend this method to regions of more general shape. Chapter 8 is devoted to the development of the Fourier series in complex form. In Chapter 9, the applications to the solutions for regions bounded by a circle are given with many important practical examples. The circular ring problem is covered in great detail in Chapter 10. The extension of the use of the power series to problems where the boundaries are of more general shape by means of conformal mapping is discussed in Chapter 11. The application is given for the case of simply connected regions such as mapping onto a circular ring and also the solution of the fundamental problem for a continuous ellipse. An interesting note is added which shows that a solution to this problem previously given by A. Timpe in 1923 was incorrect and a recent solution given by D. I. Sherman agrees with the one in the text.

Parts IV and V are concerned primarily with the fundamental properties of Cauchy integrals and their application to the solution of boundary problems of plane elasticity. Chapter 12 presents the definition of Cauchy integrals, the principal value and boundary values, and the derivatives of the Cauchy integrals. Chapter 13 is concerned with the formulation of the boundary values of holomorphic or analytic functions and the application of potential theory for a circle and half-plane.

The application of the Cauchy integrals is elegantly covered in Chapters 14–17. The treatment covers such topics as: the reduction of the fundamental problems to functional equations, to Fredholm equations and the existence theorems for them, with the corresponding applications. Various practical solutions of mapping by rational functions and also general methods are presented. The author includes other methods of solution as presented by various researchers.

Part VI treats the solution of the boundary problems of the plane theory of elasticity by reduction to the problem of linear relationship. The term, linear relationship of the boundary-value, is used by Muskhelishvili to represent the reduction to a single boundary problem of complex function theory. (This problem is completely covered in the author's book "Singular Integral Equations," also translated by Radok.) The four chapters in this part treat the development of

For information on IAS Library Service Facilities, see page 95

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

the problem from the first principles and apply the methods of solution to the problem of the half-plane, plane with straight cuts, regions bounded by circles, infinite plane cut along circular arcs, regions mapped on to a circle by rational functions, and specific related problems.

Part VII considers the problems of the extension, bending, and torsion of cylindrical homogeneous and compound bars, which are of practical interest. The problem of Saint Venant is treated basically, with the additions of certain results which represent applications of the complex function theory. The topics treated are complex torsion functions, stress functions, applications of conformal mapping, torsion of bars of different materials, extension and bending of bars of different materials with uniform Poisson's ratio, and extension and bending of bars with different Poisson's ratio.

The concluding phase of the book consists of three appendixes covering a concise introduction to the concept of a tensor, the determination of functions from their differentials in multiply-connected regions, and determination of a function of a complex variable from its real part.

The book is very impressive and excellently written, containing information in a well-printed and easily accessible form. The translator is to be highly congratulated for his elegant treatment of the translation and for inserting explanatory footnotes and additional indexes which augment the rich contents of the subject matter. This book may well be considered the classic text in the field of the theory of elasticity and is a very valuable addition to the technical literature. The publisher should be commended for the excellent appearance of the book.

HARRY ZUCKERBERG
Professional Engineer
New York, N.Y.

Book Notes

AERODYNAMICS

Gasdynamik. Klaus Oswatitsch. Vienna, Springer Verlag, 1952. 456 pp., illus., diagrs., figs. $18.60.

This book is a comprehensive presentation of current knowledge in the field of gas dynamics defined as the theory of flow of compressible media. The flow medium is treated exclusively as a continuum; topics falling within the field of the kinetic theory of gases are not considered. Dr. Oswatitsch, who is associated with the Royal Swedish Institute of Technology, Stockholm, has placed emphasis on a graphic treatment of physical and technical problems rather than on a summary or review of mathematical problems or methods of calculation. Literature references are given at the ends of sections, and there is a subject and author index.

Contents: (1) Thermodynamics. (2) Stationary one-dimensional flow. (3) Nonstationary flow. (4) General equations and theorems. (5) Special applications of integral theorems. (6) General equations and special exact solutions for stationary frictionless flow. (7) Stationary, frictionless, plane, and axisymmetric subsonic flow. (8) Stationary, frictionless, plane, and axisymmetric supersonic flow. (9) Stationary, frictionless, transonic flow. (10) Special stationary and nonstationary three-dimensional flows. (11) Flows with friction. (12) Review of experimental technique, analogies.

The Secondary Flow in Curved Pipes. Ralph W. Detra. (Zurich, Eidgenössiche Technische Hochschule, Institut für Aerodynamik, Mitteilungen Nr. 20.) Zurich, Verlag Leemann, 1953. 50 pp., illus., diagrs., figs. Sw. fr. 15.50.

In this work a study is made of the fluid flow in a curved pipe. Discussed first from a physical point of view, a basis for the origin of the phenomenon which arises is suggested; experimental results are then used to support this physical argument. In utilizing this information, a first order theory is developed to predict the flow phenomenon in a curved pipe whose cross-sectional dimensions are small compared to its radius of curvature and whose angle of bend is small. As such, the theoretical study is a study of the initial phases of the secondary flow phenomenon in a curved pipe. An application of this theory is then made, the results of which are compared with the experimental results mentioned above.

AIRPLANE DESIGN

Proceedings of the First National Turbine Powered Air Transportation Meeting, Seattle, August 9–11, 1954. Sponsored by the Institute of the Aeronautical Sciences in Cooperation with the Seattle Section of the IAS. New York, Institute of the Aeronautical Sciences, 1954. 218 pp., illus., diagrs., figs. $3.50 (nonmember price, $6.00).

Contents: Up and Down and Round and Round (Excerpts from Dinner Address), Leonard S. Hobbs. Turbine Powered Transports, Lt. Gen. Joseph Smith. Airline Turbine Transport Considerations, M. G. Beard and F. W. Kolk. CAA and Turbine Powered Transportation, F. B. Lee. Long-Range Propeller-Turbine Engined Transports, W. J. Strang. Some Design Considerations in the Development of the Douglas Model YC-124B Turbo-Prop Transport, D. L. Elder. Design Considerations of the Boeing Model 707, M. L. Pennell. Turbo-Propeller Engine Application to Transport Aircraft, Philip A. Colman. Some Performance Considerations of a Jet Transport Airplane, G. S. Schairer and M. Lynn Olason. Operational Characteristics of Turbo-Prop Propellers, G. W. Brady. Stopping Large Jet Airplanes, J. E. Steiner. Turbine Engines for Transport Airplanes, Abe Silverstein and Bruce T. Lundin. Selection of Fuels for Commercial Turbine Powered Aircraft, C. R. Johnson, E. R. Kennedy, and W. S. Little. Waterbasing the Jet Transport, Marvin I. Haar. Jet Streams and Project Skyfire, Vincent J. Schaefer.

The Shape of the Aeroplane. James Hay Stevens. London, Hutchinson & Co., Ltd., 1953. 302 pp., illus., diagrs., figs. 12*s*. 6*d*.

In sketching the development of heavier-than-air flight, the author has based his story upon the changing appearance of airplanes. In describing the reasons for the change in the airplane's appearance, he discusses the influence of air racing and record-breaking flights, the effects of war and of international trade, and political decisions. The book contains 280 illustrations of different types of aircraft.

Contents: (1) The Pioneers—Before the 1914 War. (2) The Influence of War. (3) The Hopes of Peace. (4) The Fashions of the Thirties. (5) The Stressed-Skin Monoplane. (6) The Fighter in the Second War. (7) The Rise of the Jet Fighter. (8) The Bomber—From Piston to Jet. (9) The Growth of the Transport Aeroplane. (10) Light Aeroplanes and Trainers. (11) Flying Boats and Their Future. (12) Some Special-Purpose Aeroplanes. (13) Deltas and Tailless Aeroplanes. (14) High-Speed Flight and the Future. Appendix (Glossary). Index.

AIRPLANE OPERATION

Flight Engineers Manual. Charles A. Zweng. 3rd Ed. North Hollywood, Calif., Pan American Navigation Service, November, 1954. 304 pp., illus., diagrs., figs. $5.00.

This new edition contains new material chiefly on the Civil Air Regulations and the written air examination. It includes sample examinations on the Lockheed Super Constellation Model 1047 and the Douglas DC-7.

AIRPLANE PERFORMANCE

Optimum Climbing Techniques for High-Performance Aircraft. Maurice A. Garbell. (Garbell Aeronautical Series No. 8.) San Francisco, Garbell Research Foundation, 1953. 70 pp., illus., diagrs., figs. $3.25.

In this study a set of optimum climbing techniques is introduced, which accomplish for any type of high-speed aircraft the following objectives: (1) minimum time, (2) minimum distance (steep slope of climb), and (3) minimum fuel consumed. Theoretical concepts and practical methods are provided for determination of: optimal climb to desired cruising condition, that is, to a desired combination of geometric altitude and airspeed; and the most economical climb to a desired geometric altitude regardless of airspeed. Numerical examples comprising a broad range of aircraft performances are presented. Quantitative gains and losses are shown for a current propeller-driven aircraft and for two turbojet aircraft of the immediate future.

ELECTRONICS

Cooling of Airborne Electronic Equipment and Rotating Electrical Machines, Volume 1. Papers Contributed to The Second Conference at The Ohio State University, Columbus, June 23–24, 1953. Sponsored by The Ohio State University Research Foundation and Wright Air Development Center. State University, Columbus, 1953. 213 pp., illus., diagrs., figs.

Volume 1 contains the text and figures of 33 papers presented at the conference. Volume 2 is presumably not releasable at present since it contains several classified contributions.

Proceedings of the Conference on Cooling of Airborne Electronic Equipment, 1952. Held at The Ohio State University, Columbus, under the Sponsorship of the College of Engineering of The Ohio State University, The Ohio State University Research Foundation, and Wright Air Development Center, March 20–21, 1952. (Engineering Experiment Station Bulletin No. 148.) State University, College of Engineering, Columbus, 1952. 216 pp., illus., diagrs., figs.

These proceedings are intended to serve as a record of papers, notes, and selected informal discussions presented. The 43 papers reproduced describe the current state of development in this phase of technology, and many factual data are presented.

LAWS & REGULATIONS

U. S. Aviation Reports 1945–1952, Second Cumulative Digest. Arnold W. Knauth, Henry G. Hotchkiss, Emory H. Niles, Editors. Baltimore, United States Aviation Reports, Inc., 1954. 619 pp., illus., diagrs., figs. $25.

This volume is a specialized working tool for administrators, lawyers, and students confronted with problems of aviation law under the Anglo-Saxon legal system. It should be of value to those who are concerned with the operation of air transport services, airports, and government regulation.

Contents: Table of Jurisdictions 1945–1952. Table of Cases, 1945–1952, with Cross Citations. International Conventions, Treaties and Agreements. Digest of State Legislation, 1945–1952.

ENGINEERS OR PHYSICISTS FOR RESEARCH PERTAINING TO ROCKET PROPULSION

Recent graduates with professional degree or Ph.D. received since 1945 are required for:

(1) Research in combustion stressing fluid dynamical aspects.

(2) Research in non-steady fluid flow with energy and mass transfer.

Research engineer and test engineer (MS, mechanical or chemical) are required to engage in experimental programs.

Airmail your summary of qualifications to:

Caltech

JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena 3, California

RESPONSIBLE POSITIONS FOR ENGINEERS, PHYSICISTS, MATHEMATICIANS

WEAPON SYSTEM ANALYSIS AND WEAPON SYSTEM PLANNING OF GUIDED MISSILE PROJECT

Openings exist for qualified personnel with two to ten years' experience in Aeronautics, Electronics, Applied Mathematics, Technical Economics or Physics. Fields of work include:

OPERATIONS RESEARCH
WEAPON EFFECTS
TECHNICAL ECONOMICS
LONG RANGE PLANNING
INVESTIGATION OF NEW WEAPON CONCEPTS

Degrees desired are the Bachelor's or Master's degree in Aeronautical or Electronic Engineering, Ph.D. in Mathematics or Physics or the Master's degree in Business Administration or Economics when coupled with an engineering B.S. Please forward personal resume to:

MISSILE & CONTROL EQUIPMENT DEPT. R
Engineering Personnel

NORTH AMERICAN AVIATION, INC.
Downey, California

TO STRUCTURE ENGINEERS

...with vision

Bell Aircraft is offering unlimited opportunities to structures engineers with creative ability. Bell's new approach to the fields of vertical takeoff, reconnaissance and fighter aircraft requires engineers with imagination.

We are looking for the same type of engineers who 10 years ago launched Bell on its pioneering program into supersonic and high altitude flight with such famous aircraft as the X-1, the X-2 and the 1650 m.p.h. X-1A.

Today Bell offers structures engineers challenging assignments involving the so-called *"thermal barrier"* in supersonic and hypersonic flight. By helping to insure the success of tomorrow's revolutionary aircraft, you will have the opportunity to demonstrate your ability to the fullest. Excellent positions are now available for the following:

2 Project Structures Engineers **6 Structures Design Engineers**
3 Structures Research Engineers **12 Stress Analysts**
6 Structures Leadmen **5 Weight Engineers**

At Bell, you receive top pay and liberal benefits including Life Insurance, Hospitalization, Surgery, Paid Holidays, Sick Leave, Vacations and Educational assistance.

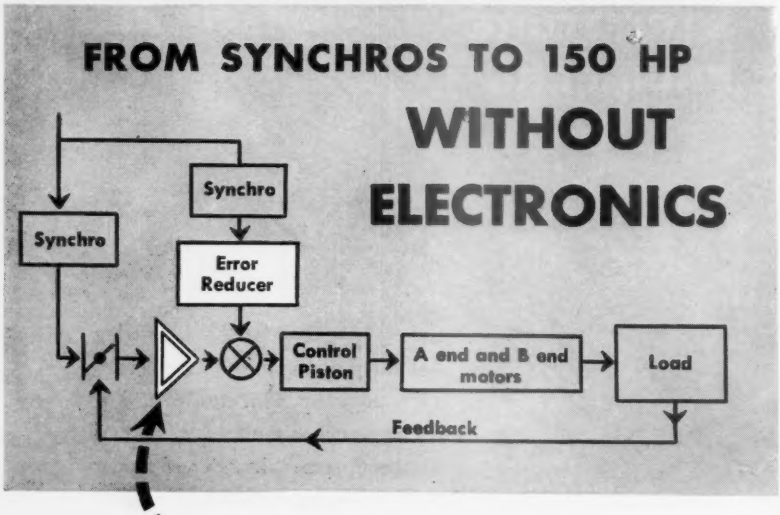
Our Chief of Structures will review your qualifications. To arrange a personal interview send your resume' to: Manager, Engineering Personnel

BELL *Aircraft* CORPORATION

P. O. BOX ONE • BUFFALO 5, N. Y.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

FROM SYNCHROS TO 150 HP WITHOUT ELECTRONICS



HYDRAULIC AMPLIFICATION

Ford engineers have developed a highly accurate synchronizing gun drive that is amplified from a small synchro motor to 150 horsepower purely by hydraulic amplification. With the addition of the Ford-perfected Error Reducer, the drive controls the power to train and elevate the guns, thus achieving continuous aiming of the guns with extremely high accuracy. Full use is being made of this experience with hydraulic servo gun drives in Ford's current work on reactor controls.

This hydraulic amplifying system is typical of the unusual amplifying systems developed by Ford Instrument Company over the past forty years. Other examples are the electronic amplifier circuits in mission control computers for the Navy Bureau of Aeronautics, magnetic amplifier circuits for power drives, and transistor amplifiers for missile guidance systems.

If you have a problem in control engineering, Ford Instrument Company's forty years of experience in high precision design and production will help you find the answer. 39

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

Digest of Federal Legislation, 1945–1952. Digest of Executive Orders, 1945–1952. Table of Reports, and Essays in the International Section, 1945–1952. Cumulative Index-Digest, 1945–1952.

MATERIALS

Thermal Conductivity of Metals and Alloys at Low Temperatures; A Review of the Literature. Robert L. Powell and William A. Blanpied. (National Bureau of Standards, Circular No. 556.) Washington, Superintendent of Documents, September 1, 1954. 68 pp., figs. $0.50.

The present Circular includes tables of measured values of thermal conductivity for metals and alloys from room temperature down to approximately 0°K. The more extensive and important data are plotted in 48 graphs. The data are essentially complete for literature references from 1900 to early 1954. For comparison, several graphs and tables are given for some representative dielectrics.

MATHEMATICS

Handbook of Elliptic Integrals for Engineers and Physicists. Paul F. Byrd and Morris D. Friedman. (Die Grundlehren der Mathematischen Wissenschaften in Einzeldarstellungen, Vol. 67.) Berlin, Springer-Verlag, 1954. 355 pp., figs. DM 36.–.

Although the book is not a text, an attempt has been made to write it in elementary terms so that no previous knowledge of elliptic integrals, theta functions, or elliptic functions is needed. A collection of over 3,000 integrals and formulas, designed to meet most practical needs, is presented using Legendre's and Jacobi's notations, rather than the less familiar Weierstrassian forms. Many of these formulas are substitutions and recurrence relations for evaluating additional integrals which are not explicitly written. Sufficient explanatory material and cross references are given to permit the reader to obtain the answers he requires with a minimum of effort. The general plan of the handbook is as follows: The definitions and other basic information concerning the elliptic integrals and Jacobian elliptic functions are given first. Then elliptic integrals in the various algebraic or trigonometric forms in which they are encountered in practice are expressed in terms of integrals involving Jacobian elliptic functions. These latter functions are then integrated. Specific reference is made in each formula (Section 200–299) to the applicable formula in tables in which the Jacobian forms are explicitly integrated. This procedure was adopted because in this way it is possible to give in less space evaluations of a variety of elliptic integrals, particularly those leading to elliptic integrals of the third kind. The remainder of the handbook is devoted to auxiliary formulas and related integrals. The authors are aeronautical research scientists with the NACA.

Tensor Calculus. Barry Spain. Edinburgh and London, Oliver and Boyd; New York, Interscience Publishers, Inc., 1953. 125 pp., figs. $1.55.

The object of this book is to provide an exposition of fundamental results in the theory of tensors and also to illustrate the power of the tensor technique by applications to differential geometry, elasticity, and relativity. In Chapter 7, Cartesian Tensors—Elasticity, the following topics are discussed: Orthogonal transformations; rotations; Cartesian tensors; infinitesimal strain; stress; equations of equilibrium; generalised Hooke's law; isotropic tensors; homogeneous and isotropic body; curvilinear coordinates; and mechanics of continuous matter. Dr. Spain is Lecturer in Mathematics at Trinity College, Dublin.

PHOTOGRAPHY

High-Speed Photography, Volume 5. New York, Society of Motion Picture and Television Engineers, 1954. 359 pp., illus., diagrs., figs. $4.50.

This volume consists of 37 appropriate papers first published in the Society's monthly Journal since the issuance of Volume 4 of this series and is largely related to the First International Symposium on High-Speed Photography which was held in Washington in 1952. Included is a cumulative index to Volumes 1–5.

PHYSICS

Molecular Theory of Gases and Liquids. Joseph O. Hirschfelder, Charles F. Curtiss, and R. Byron Bird, with the assistance of the Staff of the University of Wisconsin Naval Research Laboratory. New York, John Wiley & Sons, Inc., 1954. 1,219 pp., diagrs., figs. $20.

This book describes the properties of gases and liquids from a "molecular" point of view. These properties are divided into two groups—the equilibrium properties (such as the equation of state, Joule-Thomson coefficient, and surface tension) and the nonequilibrium properties (such as viscosity, diffusion, and thermal conductivity). During the last decade many theoretical, computational, and experimental developments have been made in the study of the properties of gases and liquids. The authors have surveyed this entire field from a unified point of view and have presented it in consistent notation. The book should be found useful by students in chemical physics and statistical mechanicians. The chapters on calculations on the properties of gases and liquids should be of value in design work to experimental physical chemists and to industrial engineers. Extensive tables are included and numerical examples illustrate their use. The work, which grew out of studies undertaken in the Bumblebee program sponsored by the Naval Bureau of Ordnance, is a synthesis of contributions by a large number of people and is a partial answer to the request of the Research and Development Board for a report on the status of research in the fields of the equation of state and transport phenomena. It is also an outgrowth of a National Defense Research Committee Report (A-116, 1942) entitled "The Thermodynamic Properties of Propellant Gases," written by J. O. Hirschfelder, F. T. McClure, C. F. Curtiss, and D. W. Osborne.

Contents: Note on Notation. Vector and Tensor Notation. Chapter 1, Introduction and Background Information.

Part I, Equilibrium Properties. Chapter 2, Statistical Mechanics. Chapter 3, The Equation of State of Gases at Low and Moderate Densities. Chapter 4, The Equation of State of Dense Gases and Liquids. Chapter 5, Vapor-Liquid Equilibria and Critical Phenomena. Chapter 6, Quantum Theory and the Equation of State.

Part II, Non-Equilibrium Properties. Chapter 7, The Kinetic Theory of Dilute Gases. Chapter 8, Transport Phenomena of Dilute Gases. Chapter 9, The Transport Properties of Dense Gases and Liquids. Chapter 10, Quantum Theory and Transport Phenomena. Chapter 11, Hydrodynamic Applications of the Equations of Change.

Part III, Intermolecular Forces. Chapter 12, Electromagnetic Basis of Intermolecular Forces. Chapter 13, The Theory of Intermolecular Forces. Chapter 14, Quantum Mechanical Calculations of Intermolecular Forces. Appendix (Tables). Symbols and Notation. Chemical Index. Author Index. Subject Index.

RESEARCH

Directory of Industrial Research Laboratories of New York State, 1954. Albany, N.Y., State Department of Commerce, 1954. 126 pp.

The Directory of Industrial Research Laboratories in New York State contains 652 laboratory listings, divided into three separate sections, and a subject index of fields of research. The Subject Index of Research Activity lists the various fields of research carried on by those laboratories which offer consultation and accept work projects from other firms, agencies, or individuals.

(*Continued on page 130*)

TO THE FINE ENGINEERING MIND
SEEKING THE CHALLENGING PROJECTS IN

DYNAMICS

Convair, in beautiful San Diego, California, now offers exceptional career opportunities to **DYNAMICS ENGINEERS** with experience in: general flight and control dynamics for both airplane and missile design – analysis and synthesis of servomechanisms, autopilot design, controls and computers – aeroelasticity, fluid dynamics, vibration and flutter – aerodynamic, dynamic, and transient load analysis – solution of dynamic problems by analytical methods and by analog machine computations. Special opportunities for men holding advanced engineering, physics, or mathematics degrees.

At **CONVAIR** you will find an imaginative, explorative, energetic engineering department . . . truly the "engineer's" engineering department to challenge your mind, your skills, your abilities in solving the complex problems of vital, new, long-range programs. You will find salaries, facilities, engineering policies, educational opportunities and personal advantages excellent.

Lovely, sunny, **SMOG-FREE SAN DIEGO**, ever-growing area of three-fourths million people, offers you and your family a way of life judged by most as the Nation's finest for climate, natural beauty and easy (indoor-outdoor) living. Housing is plentiful and reasonable.

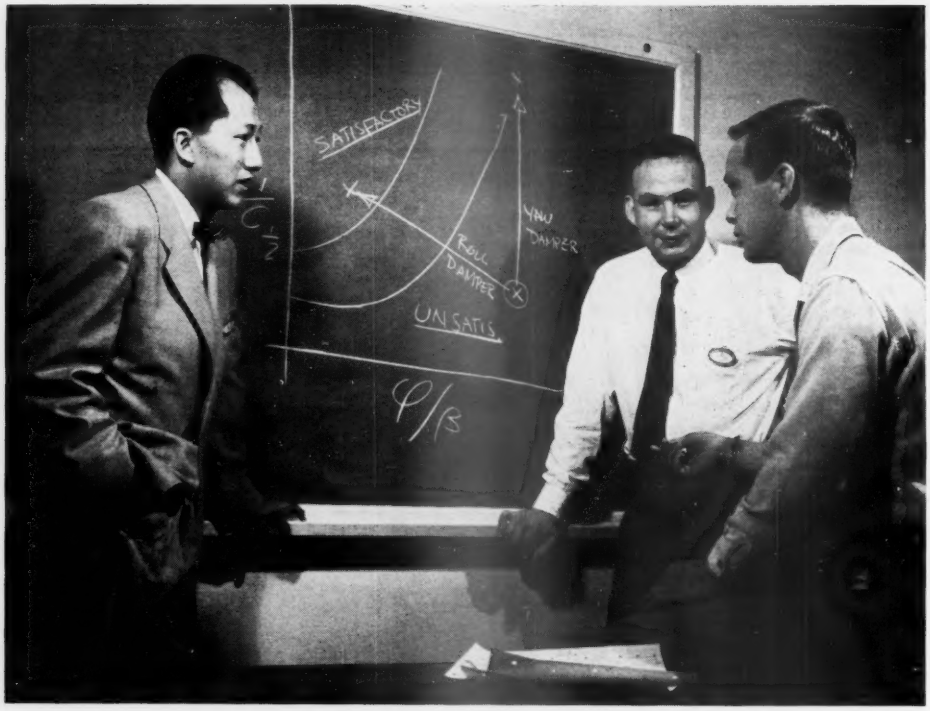
Generous travel allowances to engineers who are accepted. Write at once enclosing full resume to:

H. T. Brooks, Engineering Personnel, Dept. 501

CONVAIR

A Division of General Dynamics Corporation

3302 PACIFIC HIGHWAY SAN DIEGO, CALIFORNIA



Jim Hong, Aerodynamics Division head (left), discusses effects of auxiliary damping devices on roll-to-yaw ratio requirements for desirable flying characteristics of a supersonic fighter with Richard Heppe, Aerodynamics Department head (center), and Aerodynamicist Bob Scott (right).

XFV-1 Vertical-Rising Plane
In development: advanced versions of vertical-rising aircraft.

Jet Trainer
In development: Jet trainers which will simulate flight characteristics of any plane.

In development: Jet fighters with speeds far exceeding those of present-day aircraft.

F-104 Supersonic Superiority Fighter (Photographs and flight performance are classified)

P2V-7 Neptune Patrol Bomber
In development: (Projects in the bomber field are classified).

R7V-2 Turbo-Prop Transport (world's fastest propeller-driven plane)
In development: Advanced versions of the Super Constellation.

C-130 Turbo-Prop Transport
In development: Jet transports, other types of cargo planes.

Six Prototypes Show Trend of Lockheed Aerodynamics Progress

Aerodynamics engineers work in a realm of classified activity. Their accomplishments become known only when a plane first flies or is declassified – long after the Aerodynamics work is done.

That is why Lockheed's six prototypes are so significant to career-minded Aerodynamics Engineers.

Ranging from hovering to supersonic flight, the prototypes individually are aerodynamics achievements. Collectively they demonstrate the versatility and scope of Lockheed's Aerodynamics Staff.

They emphasize the creative atmosphere at Lockheed. For with Lockheed activities covering virtually every phase of aeronautical endeavor, fresh thinking, new ideas are welcomed and rewarded.

Moreover, the variety of the prototypes point out the path of Lockheed's Aerodynamics future: significant advances in *all phases* of aircraft, commercial and military.

AERODYNAMICS CAREER OPPORTUNITIES – This diversified expansion program has created new positions for Aerodynamicists at all levels to: create supersonic inlet designs for flight at extremely high altitude; match human pilots with rapid oscillations of supersonic aircraft at low altitude; develop boundary layer control systems for safe take-off and landing of fighters and transports; remove aileron reversal and tail flutter problems incurred in high-speed flight through analysis and design; participate in determining configurations of turbo-prop and jet transports and advanced fighters, interceptors and bombers.

Aerodynamics men interested in those problems are invited to write E. W. Des Lauriers, Dept. AER-A-1, for an application blank and brochure describing life and work at Lockheed.

Lockheed
AIRCRAFT CORPORATION
BURBANK **California**

$8,360 per annum. Chief of Development Section—Supervises the planning, testing, and evaluation of all projects concerning guided-missile recovering, specialized equipment recovery, and all parachute research projects. Responsible for the design and development of specialized vehicles and test equipment. Supervises the aerodynamics and ballistics and the data-evaluation group. Experience in aerodynamics preliminary design and flight-test engineering desirable. M.S. or B.S. in aeronautics required. Three **Aeronautical or Mechanical Engineers**—GS-9 to GS-11, $5,060 to $5,940 per annum. For development work in missile recovering, high-speed parachute recovery of ordnance and airborne equipment, and high-speed aircraft escape and for aerodynamics and ballistics calculation and data evaluation of high-speed test vehicles and general parachute recovery work. **Engineering Draftsman or Designer**—GS-7; to work on design of specialized recovery equipment, aircraft installations, and modification of airborne equipment. Must be able to work independently from sketches. Experience in general aeronautical design required. Submit applications to Commander, 6511th Test Group (Parachute), NAAS, El Centro, Calif.

Engineers—General Electric's new Small Aircraft Engine Department in New England, concerned with design, development, and manufacture of small gas-turbine power plants for varied aircraft types, offers positions for mechanical engineers. These positions involve engine design and engine component design, including both rotating and static parts, and stress and vibration analysis of highly loaded members such as compressors, turbines, blades, and buckets. Additional positions involve combustion systems and afterburner designs for advanced prototype engines. Send résumé to: E. P. Barrett, SAED, General Electric Company, West Lynn, Mass.

Engineer-Instructor—The Test Pilot Training Division of the Naval Air Test Center, Patuxent River, Maryland, has a position available for a young engineer as Assistant Performance Engineer (salary $3,410 to $5,060 per annum, commensurate with experience and graduate work). The work of this position is equally divided between teaching aircraft performance testing theory and methods and conducting specialized research performance projects on jet aircraft. Opportunities are available to gain broad experience in the theory and practice of performance determination of new aircraft and engines; to advance in position and salary; to associate with a well-recognized aircraft test center and school; and to participate in an off-campus graduate study program leading to a Master's Degree. Teaching experience is not necessary but is considered an assist. Please send résumé, preferably on Civil Service Standard Form 57, to Chief Engineer.

Engineers—Leading Virginia research and development organization has outstanding opportunities for capable and qualified men who can fill the following positions in an expanding program on guided missile propulsion systems. **Project Engineer**—to direct and supervise development and pilot production; men of eight years' applicable experience desired. **Mechanical Designers**—for design and construction supervision of components for missile engines; 5 years' experience desired with emphasis on experience in design of rotating equipment. **Design Draftsman**—for detail work on design of propulsion system components; 3 years' experience desired. **Stress and Vibration Analysts**—for theoretical and experimental studies of rotating components; 5 years' experience desired. Please furnish detailed résumé and address all inquiries to Personnel Manager, Experiment Incorporated, Richmond 2, Va.

Professors—The USAF Institute of Technology, Wright-Patterson Air Force Base, Ohio, has vacancies in the Department of Mathematics. Most of the work is at advanced undergraduate and graduate level. Employment will be effected in accordance with Civil Service regulations. Grade levels available are: GS-9 ($5,060), instructor; GS-11 ($5,940), assistant professor;

C. H. Fish, design engineer assigned to the Icing Research Tunnel, measures impingement limits of ice on C-130 wing section. The tunnel has a temperature range of −40°F. to +150°F. and maximum speed of more than 270 mph.

Lockheed Increases Thermodynamics Staff

With six prototypes now in flight, Lockheed's Thermodynamics Department is expanding its staff to handle greatly increased research and development on future aircraft in commercial and military fields.

Lockheed's new icing tunnel, designed and installed to help handle the increased work load, is already in operation. It is the first icing research tunnel in private industry, and gives Lockheed's Thermodynamics Department unmatched testing facilities.

The tunnel enables Lockheed thermodynamics scientists to study in greater detail such problems as: thermal anti-icing; cyclic de-icing; various methods of ice removal; distribution of ice; rate of temperature changes in aircraft components; thermodynamic correlation between laboratory and flight testing; and development and calibration of special instrumentation.

Thermodynamics Career Opportunities—A number of new positions have been created by Lockheed's diversified expansion program. Thermodynamics assignments include such diverse projects as nuclear energy; supersonic fighters, trainers and transports; advanced versions of vertical-rising aircraft and bombers; turbo-prop transports; and a number of significant classified activities.

Lockheed offers you increased salary rates now in effect; generous travel and moving allowances; an opportunity to enjoy Southern California life; and an extremely wide range of employee benefits which add approximately 14% to each engineer's salary in the form of insurance, retirement pension, sick leave with pay, etc.

You are invited to write E. W. Des Lauriers, Dept. AER-T-1, for a brochure describing life and work at Lockheed and an application blank.

LOCKHEED
AIRCRAFT CORPORATION
BURBANK **CALIFORNIA**

and GS-12 ($7,040), associate professor. Applications should be made on Standard Form 57, available at any Post Office, or by letter to Head of the Department of Mathematics, Resident College, USAF Institute of Technology, Wright-Patterson Air Force Base, Ohio.

648. Design Engineers—Positions open for designers with helicopter experience, particularly in mechanical design. Eastern company with excellent prospects. Salary open, and depends upon ability and experience. Enclose résumé of education and experience with reply.

Available

647. Advertising and Public Relations Manager—B.S. Engr./Bus. Admin., M.B.A. Marketing. 10 years' progressive experience in all phases of industrial marketing. Program planning, budgeting and administration, market survey, agency liaison, media evaluation, copywriting, and production. Pamphlets, brochures, catalogs, direct mail, trade shows, technical publicity. Media, industry, and Government relations. Licensed pilot, mechanic, and radio operator with background in air transport, aircraft and electronic equipment. Desires career position offering greater responsibilites and advancement opportunities. Age 35.

646. Manager—Engineering or Manufacturing. A.E. degree with 15 years of aircraft and aircraft equipment experience. Broad background in equipment design and manufacture, engineering administration, production control, purchasing, machine shop, and assembly operation. Also traveled extensively in sales engineering capacity. Capable of building up small organization. New England location preferred.

645. Design Engineer—B.S., M.S. in Aeronautical Engineering. 12 years of aircraft and guided missile experience (research and development). Extensive aeronautical background coupled with supervisory and administrative know-how. Completely familiar with Naval Aviation military requirements. Desires staff level position with progressive organization. Principals only.

644. Engineering Executive—B.S. Aero. Engineering; preparing for M.B.A., Columbia University (Evenings). 7 years' aircraft experience; 5 years Chief Engineer small aircraft company; helicopter and airplane project and design experience; familiar with government procurement operations. Desires engineering executive or sales engineering position (New York area) with future and challenge. Readily accepts responsibility. Excellent references. Age 28.

643. Engineer-Writer—Mature; M.S. in General Enginering; heavy experience in aeronautical engineering, particularly stress analysis; diversified patent design and technical writing on aeronautical, mechanical, civil engineering projects. Desires connection with progressive organization, New England or Far West location.

642. Engineer—M.S., with extensive background in aeronautical engineering; major structural analysis; technical writing; varied experience with general engineering projects. Traveled. Desires teaching position or research with school or university, preferably New England or California. Résumé on request.

641. Engineer—B.S.Ae.E., 1948. Total engineering experience over $7\frac{1}{2}$ years, of which $6\frac{1}{2}$ years are full time. Two and one-half years' experience on high-pressure aircraft hydraulic systems and missile component design. Two years as design engineer on small electromechanical components, and two years as development engineer on component packaging of missile automatic flight controls. Background includes multiengined commercial pilot's license, military flying experience, and aircraft maintenance officer USAF Reserve. Desires position of greater responsibility in technical or administrative field. Location preferred—South, West, or Texas. Résumé will be sent upon request showing position(s) available.

639. Research Pilot—B.S.I.A.; age 34. Com'l. Certificate, MEL, SEL, currently acquiring CAA Ins't. rating. Have held USAF Instructor's ratings since 1944. Air experience in Europe, United States, and Alaska, predominately MEL with concurrent work in meteorology. Professional member, American Meteorology Society and former practicing forecaster. Some aircraft manufacturing background including engine test, patent, administrative, and supervisory experience. Desires position emphasizing MEL piloting and meteorology. Salary and location secondary.

638. Technical Administrative Engineer—B.S.M.E.; age 41. Sixteen years in aircraft engineering including 2 in mechanical laboratory, 10 in structural test, and 4 in missile structural and mechanical development at increasingly responsible levels. Experienced organizer, able to get top results in design, development and testing of mechanical and electromechanical systems and structure. Desires responsible position with a challenge. Present salary $12,000. Personal résumé on request.

Books

(*Continued from page 125*)

SPACE TRAVEL

Forschung zwischen Luftfahrt und Raumfahrt. Eugen Sänger. Tittmoning, Oberbayern, Germany, Verlag Walter Pustet, 1954. 93 pp., diagrs., figs. DM 3.90.

Doctor Sänger discusses the scientific, technical, economic, and organizational problems that must be solved in making the transition from aeronautics to space travel and summarizes in general terms the progress that has been made to date. He proposes in outline a research program in various branches of science and engineering which would lead toward the accomplishment of travel outside the earth's atmosphere.

Literaturverzeichnis der Astronautik (Literature-Index of Astronautics). H. H. Koelle and H. J. Kaeppeler.[5] Tittmoning, Oberbayern, Germany, Verlag Walter Pustet, 1954. 100 pp. DM 6.40.

This bibliography contains over 1,600 references to original work in the fields of aeronautics and space-travel research and is intended as a representative cross section of the available literature rather than a systematic collection of all publications on the subject. The references are arranged by subject according to a decimal classification devised by Doctor E. Sänger. Included are a list of periodicals and an author index.

SPECIFICATIONS

U.S. Government Specifications Directory; Purchasing Specifications of Military and Civilian Agencies: Where to Find Them, Pointers on Their Use. Small Business Administration. Washington, Superintendent of Documents, 1953. 19 pp. $0.25.

The Specifications Directory discusses in detail the purchasing specifications used by the military and civilian agencies of the Government, and appropriate indexes to them; tells how the businessman may obtain copies of particular specifications or specifications indexes for continuing use; and lists more than 500 Government activities or depository libraries for Government publications where specifications and indexes to them are available for reference purposes.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be printed legibly and sent directly to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y.